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DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407


IN REPLY REFER TO:

NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 14-80

MK 16 MOD 0 UBA
TECHEVAL REPORT

JULY 1980

By: M. J. Harwood

Approved for public release; distribution unlimited.



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MK 16 MOD O UBA TECHEVAL

technical evaluation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Technical Evaluation (TECHEVAL) of the MK 16 MOD O Underwater Breathing Apparatus (UBA) was conducted by the Navy Experimental Diving Unit (NEDU) from 5 May through 13 June 1980. Specific objectives were to achieve 100 hours bottom time at depths to 150 FSW and to verify Mean Time Between Failures (MTBF) and Mean Time To Repair (MTTR). The results of the TECHEVAL revealed many deficiencies which should be corrected and tested prior to OPEVAL.

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ABSTRACT

The Technical Evaluation (TECHEVAL) of the MK 16 MOD 0 Underwater Breathing Apparatus (UBA) was conducted by the Navy Experimental Diving Unit (NEDU) from 5 May through 13 June 1980. Specific objectives were to achieve 100 hours bottom time at depths to 150 FSW and to verify Mean Time Between Failures (MTBF) and Mean Time To Repair (MTTR). The results of the TECHEVAL revealed many deficiencies which should be corrected and tested prior to OPEVAL.

Enclosures 1 thru 5, NEDU Test Plan 80-14 dated 30 April 1980 is Enclosure 1 for the entire report per Lt. Harper, NEDU

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## GLOSSARY

| | |
|---|---|
| DA | Development Agency |
| DT III | Development Testing Phase 3 |
| ECP | Engineering Change Proposal |
| EOD | Explosive Ordnance Disposal |
| EOD Det | Explosive Ordnance Disposal Detachment |
| FFM | Full Face Mask |
| FSW | Feet Sea Water |
| HP | High Pressure |
| ID | Identification |
| lbs | Pounds Weight |
| LCD | Liquid Crystal Display |
| LED | Light Emitting Diode |
| LIS | Low Influence Signature |
| mA | milli ampere |
| MTBF | Mean Time Between Failure |
| MTTR | Mean Time To Repair |
| NEDU | Navy Experimental Diving Unit |
| NAVEODFAC | Naval Explosive Ordnance Facility |
| NTP | Navy Training Plan |
| $O_2$ | Oxygen |
| O&M | Operation and Maintenance |
| OPEVAL | Operational Evaluation |
| PMS | Preventative Maintenance Schedule |
| $PO_2$ | Partial Pressure of Oxygen |
| PPM | Pre-Production Model |

| | |
|---|---|
| TEMP | Test and Evaluation Master Plan |
| UBA | Underwater Breathing Apparatus |
| VDC | Volts Direct Current |

## REFERENCES

1. TEMP #765-1 dtd 17 March 1980 (DRAFT)

2. NEDU ltr EDU:CAB:jt 3948 Serial 109 dtd 24 March 1980

## ENCLOSURES

1. NEDU TEST PLAN NUMBER 80-14 DTD 30 APRIL 1980
2. MK 16 MOD 0 UBA - NUMBER OF DIVES, DEPTHS AND DURATION
3. MK 16 MOD 0 UBA - MTBF DURING TECHEVAL
4. MK 16 MOD 0 UBA SPARE PARTS OUTFIT - PROPOSED LIST
5. MK 16 MOD 0 UBA - SPECIAL TOOL REQUIREMENTS
6. MK 16 MOD 0 UBA - TRAINING COURSE PLAN AND LEARNING OBJECTIVS - NEDU COMMENTS
7. MK 16 MOD 0 UBA - ENGINEERING CHANGE PROPOSALS (ECP'S)
8. MK 16 MOD 0 UBA - PRE-PRODUCTION MODEL (PPM) CONFIGURATION DIFFERENCES
9. MK 16 MOD 0 UBA - ADDITIONAL SPARE PARTS TO OVERHAUL UBA'S
10. MK 16 MOD 0 UBA - SUMMARY OF PRIMARY AND SECONDARY BATTERY USAGE RATES
11. MK 16 MOD 0 UBA - PRIMARY BATTERY CHARGING STATION AND METER FOR SECONDARY BATTERY CHECK WIRING DIAGRAM AND OPERATING PROCEDURES

1. Introduction

a. The Technical Evaluation (TECHEVAL) of the MK 16 MOD 0 Underwater Breathing Apparatus (UBA) (Figure 1) was conducted by the Navy Experimental Diving Unit (NEDU) from 5 May through 13 June 1980 in accordance with reference 1.

b. The MK 16 MOD 0 UBA is a Low Influence Signature (LIS) closed-circuit, mixed-gas, constant partial pressure oxygen, underwater life support system developed to support the low magnetic and acoustic signature requirements of Explosive Ordnance Disposal (EOD). The breathing medium is kept at a predetermined partial pressure of oxygen ($PO_2$) set point by use of oxygen sensors that monitor, evaluate, and control the level via a battery operated electronic module. The major individual components under development to support the LIS requirement consist of a Light Emitting Diode (LED) primary display mounted in the face mask; a plastic cased, rechargeable non-magnetic battery; a solid state, semiconductor, expendable electronics package, an LIS oxygen control valve, and a Liquid Crystal Display (LCD) secondary display (Figure 2).

c. The Objectives of the Technical Evaluation (TECHEVAL) were:

(1) Specific

(a) To achieve at least 100 hours bottom time at depths to 150 FSW.

(b) Verify a Mean Time Between Failure (MTBF) for a 4 hour mission of:

1. Life Support Subsystem Components - 158 hours for a 95% confidence level.

2. Mission Support - 38 hours for a 80% confidence level.

(c) Verify a Mean Time To Repair (MTTR) of 1 hour.

(2) Additional

(a) Verify the probability of achieving an Operational Availability such that two out of every three UBA MK 16 MOD 0's will be available at the commencement of a planned mission. (In the case of TECHEVAL this will be considered to be prior to each planned dive and Dive Supervisor check).

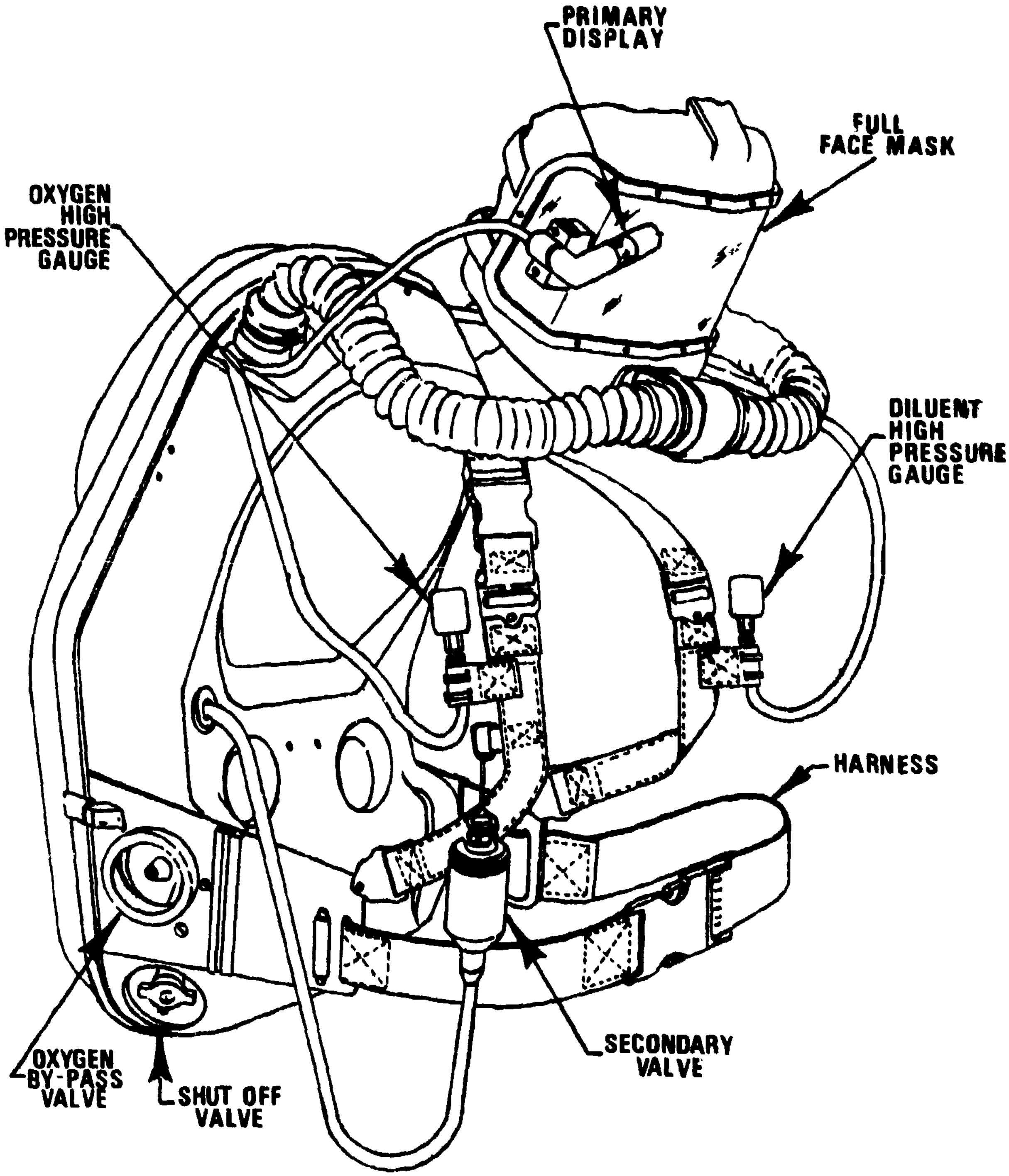
(b) Evaluate the supportability by validating the technical adequacy, content and format of the Operations and Maintenance (O&M) Manual and Preventative Maintenance Schedule (PMS).

(c) Evaluate the adequacy of the Interim Spare Parts Outfit to verify it can support PMS and corrective maintenance.

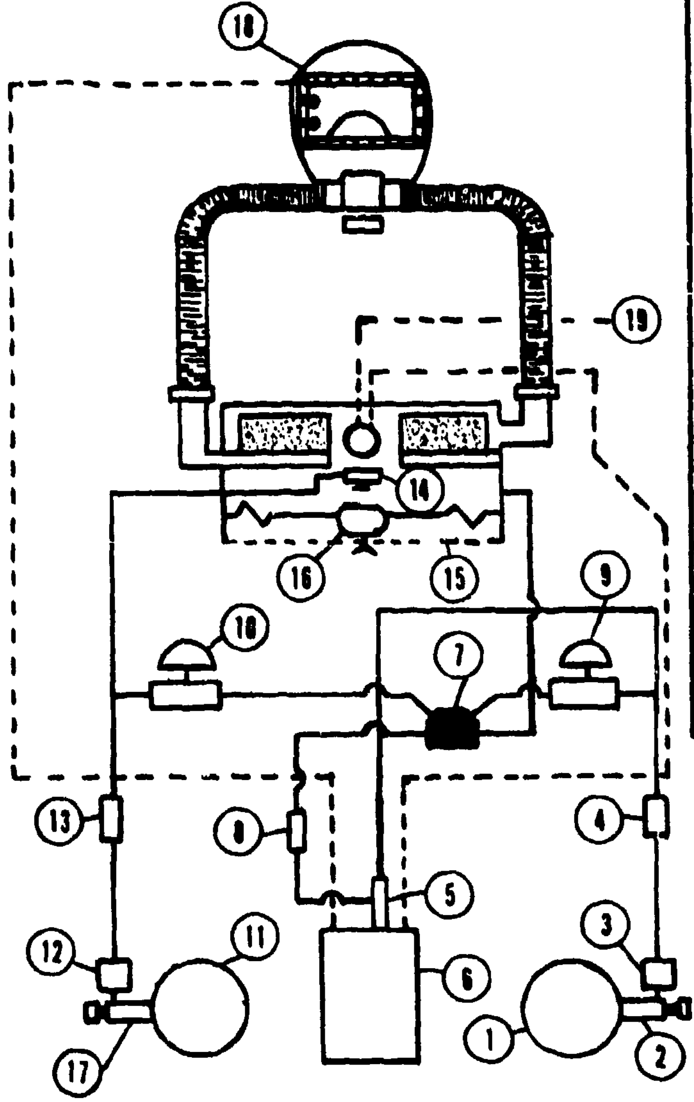
(d) Evaluate the Tool/Test Equipment provided to support turnaround maintenance, repairs, and PMS.

(e) Evaluate the proposed Training Course Plan and Learning Objectives.

(f) Continue evaluation of human engineering factors with specific attention to those areas found to be lacking during previous DT III tests.




MK 16 MOD O
UNDERWATER BREATHING APPARATUS
FIGURE 1




| INDEX NO. | DESCRIPTION |
|---|---|
| 1 | OXYGEN STORAGE BOTTLE |
| 2 | OXYGEN BOTTLE VALVE |
| 3 | OXYGEN REGULATOR |
| 4 | 4 MICRON FILTER |
| 5 | OXYGEN ADDITION VALVE |
| 6 | ELECTRONICS ASSY. |
| 7 | TUBE ASSEMBLY WELDMENT |
| 8 | CHECK VALVE |
| 9 | OXYGEN MANUAL BY-PASS VALVE |
| 10 | DILUENT BY-PASS VALVE |
| 11 | DILUENT STORAGE BOTTLE |
| 12 | DILUENT REGULATOR |
| 13 | 4 MICRON FILTER |
| 14 | DILUENT ADDITION VALVE |
| 15 | DIAPHRAGM |
| 16 | DIAPHRAGM VENT VALVE |
| 17 | DILUENT BOTTLE VALVE |
| 18 | PRIMARY DISPLAY |
| 19 | TO SECONDARY DISPLAY |

MK 16 MOD 0 UBA
PNEUMATICS SCHEMATIC
FIGURE 2

d. The TECHEVAL was conducted in accordance with NEDU Test Plan Number 80-14 dated 30 April 1980 [Enclosure (1)]. The program was extended by one week in an attempt to make up time lost due to foul weather, long transit times to the dive sites and the requirement to try and meet all the reliability hours during TECHEVAL. [Reference 2, Enclosure (1) paragraph 5 refers].

2. Summary of Diving Achieved

a. 193 MK 16 MOD 0 UBA dives were made in water depths varying from 12 to 150 FSW. [For full details see Enclosure (2).] The total water time was 305.5 hours.

3. Summary of Objectives Achieved

a. Specific

(1) 100 hours bottom time was achieved at depths to 150 FSW [See Enclosure (2)].

(2) The MTBF for a 4 hour mission was not achieved for life support subsystem components or mission support as set out in paragraph 1,c,(1),(b) above. This was due to lack of achieving the hours in the TECHEVAL time period and the number of reported failures. These failures are subject to review, and may or may not be discounted depending on the particular failure mode. The summary of MTBF failures is contained in Enclosure (3).

(3) The MTTR of 1 hour was achieved when spares were available. The lack of 2 complete spares outfits for the 6 MK 16 MOD 0 UBA's prevented a full assessment of this objective. There is no reason to believe that with a full spares outfit the MTTR of 1 hour cannot be achieved.

b. Additional

(1) The probability of achieving an Operational Availability such that two out of every three MK 16 MOD 0 UBA's will be available at the commencement of a planned mission was met during TECHEVAL.

(2) The evaluation of the supportability by validating the technical adequacy, content and format of the O&M Manual and PMS was not achieved. The DRAFT O&M Manual presented for TECHEVAL had many minor errors in the text, and the assembly exploded view drawings and parts lists were not up to date. However, this had been expected as the O&M Manual was a first cut and had been completed prior to the configuration audit. A review of the manual took place early in the TECHEVAL, and the NEDU input was forwarded direct to the software contractor and NAVEODFAC Representative. A further review of the next draft prior to OPEVAL is recommended. The PMS, as written in the manual, requires review. This will be conducted prior to OPEVAL. PMS cards were not present for TECHEVAL, and were not expected due to the late arrival of the O&M Manual.

(3) The Interim Spare Parts Outfit was far from complete, and no attempt was made to evaluate its adequacy to support PMS and corrective maintenance. However, a best attempt at producing a Spare Parts Outfit is at Enclosure (4).

(4) The Tool/Test Equipment was not reviewed during TECHEVAL. The review should take place when the PMS has been finalized. A list of tools that will be needed to conduct Pre-Dive, Post-Dive, Trouble-Shooting and PMS should be included in the O&M Manual.

(a) Special tools required, other than those in a normal EOD Det non-magnetic tool kit, are included in Enclosure (5).

(b) On completion of the reliability testing of the Primary and Secondary Batteries, the electronic test equipment requirement for the MK 16 MOD 0 UBA should be reviewed.

(5) The proposed Training Course Plan and Learning Objectives were reviewed. NEDU comments are included in Enclosure (6).

(6) The Human Engineering Factors Evaluation recommended changes during DT III have been included in Enclosure (7).

4. Primary and Secondary Battery Usage

a. A major area of concern was the high usage of both the re-chargeable primary battery and the throw-away secondary battery.

b. A summary of the battery usage is included as Enclosure (10). Both batteries need to be subjected to intense reliability testing. The results from the reliability testing should be used to produce new guidance on charging and use. This guidance must be available prior to OPEVAL.

5. Recommended Engineering Changes

a. As a result of the Human Engineering Factors Evaluations, DA Test Director Observations during DT III, and constructive comments from various sources connected with DT III; numerous Engineering Change Proposals (ECP's) are recommended either before the Operational Evaluation (OPEVAL) or before production (Enclosure (7)).

b. During DT III testing, it was noted that the 6 Pre-Production Models (PPM) of the MK 16 MOD 0 UBA were not identical. The list of differences is included as Enclosure (8). These should be corrected prior to OPEVAL.

c. Prior to OPEVAL, certain parts of PPMs 1 through 6 which had excessive use during TECHEVAL or are considered to be high usage items due to the present MK 16 MOD 0 UBA design, should be made available or replaced. These are listed in Enclosure (9).

6. Discussion

a. The MK 16 MOD 0 UBA completed NEDU TECHEVAL but did not achieve the total number of hours to verify the MTBF requirement. Also, many deficiencies were identified which should be corrected prior to OPEVAL.

b. Although the number of emergent problems experienced during TECHEVAL would indicate that the MK 16 development had not progressed to the TECHEVAL stage, many of these problems would not have been identified had open-sea testing not been conducted.

c. Recommendation: That the changes to the MK 16 MOD O UBA recommended by this report be completed and tested prior to OPEVAL.

DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407

IN REPLY REFER TO:

NAVY EXPERIMENTAL DIVING UNIT

TEST PLAN

Test Title: Underwater Breathing Apparatus
MK 16 MOD 0 Technical Evaluation

Test Plan Number: 80-14

Date: 30 April 1980

Prepared by:

M. J. Harwood

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MK 16 MOD 0 Project Officer

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Executive Officer

Approved by:

C. A. BARTHOLOMEW
CDR, USN
Commanding Officer

1. Introduction

a. The Underwater Breathing Apparatus (UBA) MK 16 MOD 0 is a Low Influence Signature (LIS) closed circuit, mixed gas, constant partial pressure oxygen, underwater life support system developed to support the low magnetic and acoustic signature requirements of Explosive Ordnance Disposal (EOD). The breathing medium is kept at a predetermined partial pressure of oxygen (PPO2) set point by use of oxygen sensors that monitor, evaluate, and control the level via a battery operated electronic module. The major individual components under development to support the Low Influence Signature (LIS) requirement consist of a Light Emitting Diode (LED) primary display mounted in the face mask; a plastic cased, rechargeable non-magnetic battery; a solid state, semiconductor, expendable electronics package, an LIS oxygen control valve, and a Liquid Crystal Display (LCD) secondary display.

b. The Objectives of the Technical Evaluation (TECHEVAL) Test are:

(1) Specific

(a) To achieve a least 100 hours bottom time at depths to 150 FSW.

(b) Verify a MTBF for a 4 hour mission of:

1. Life Support Subsystem Components - 158 hours for a 95% confidence level.

2. Mission Support - 38 hours for a 80% confidence level.

(c) Verify a MTTR of 1 hour.

(2) Additional

(a) Verify the probability of achieving an Operational Availability such that two out of every three UBA MK 16 MOD 0's will be available at the commencement of a planned mission. (In the case of TECHEVAL this will be considered to be prior to each planned dive, Dive Supervisor check).

(b) Evaluate the supportability by validating the technical adequacy, content and format of the O&M Manual and PMS.

(c) Evaluate the adequacy of the Interim Spare Parts Outfit to verify they can support PMS and corrective maintenance.

(d) Evaluate the Tool/Test Equipment provided to support turnaround maintenance, repairs, and PMS.

(e) Evaluate the proposed Training Course Plan and Learning Objectives.

(f) Continue evaluation of Human Engineering Factors with specific attention to those areas found to be lacking during previous DT III tests.

c. The training and tests will be conducted by NEDU and will take place at NEDU and Key West. Personnel will be drawn from NEDU, EODGRU ONE, EODGRU TWO, and NAVSCOLEOD.

d. The NAVEODFAC will be conducting MK 16 MOD 0 swims against the MISS (Multiple Influence Sensor System) during the same period as this test. MK 16 dive subjects will be provided from the NEDU training group. MK 16 logistic support, spares, tools and test equipment will be shared and dive hours, failures, etc. achieved during the MISS swims added to the NEDU collated figures.

2. References and Enclosures

a. References

(a) NDCP #S-1317-SW dated 19 September 1979
(b) TEMP #765-1 dated 17 March 1980 (DRAFT)
(c) ILSP #265-4 undated (DRAFT)
(d) UBA MK 16 MOD 0 O&M Manual dated 25 April 1980 (DRAFT)
(e) NTP #5-80-79 dated September 1979 Revision 3 (DRAFT)
(f) Reliability Program Plan dated November 1978 (1st DRAFT)
(g) Maintainability Program Plan dated November 1978 (1st DRAFT)
(h) System Safety Program Plan dated January 1979 (DRAFT)
(i) FMEA dated January 1979 (PROVISIONAL DRAFT)
(j) Configuration Management Plan dated November 1978 (1st DRAFT)
(k) NEDU letter EDU:CAB:jt 3948 Serial 109 dated 24 March 1980
(l) NEDU message 241348Z MAR 80
(m) NEDU message 031809Z APR 80
(n) NEDU letter EDU:MJH:cz 3948 Serial 129 dated 7 April 1980
(o) U. S. Navy Diving Manual
(p) UBA MK 15 MOD 0 O&M Manual (NAVSEA 0994-LP-016-1010)
(q) Life Preserver MK 4 O&M Manual (SS 710-AA-MMO-010/TM-LPSP/MK 4
(r) PRC O&M Manual dated July 1978 as amended by NEDU (DRAFT)

b. Enclosures

(1) Daily MK 16 MOD 0 TECHEVAL Schedule
(2) Test Procedure for MK 16 MOD 0 TECHEVAL
(3) Decompression Tables; 0.7 ATA Constant $PPO_2$ in $N_2$
(4) Extracts from the DRAFT PRC Manual
(5) MK 16 UBA TECHEVAL Accident/Incident Procedures

3. Test Number. 80-14

4. Program

a. The TECHEVAL Training Site will be at NEDU and local Panama City areas. The TECHEVAL site will be Key West, Florida.

b. Dates are:

(1) Training - 5 to 16 May 1980
(2) Travel - 17 to 18 May 1980 and 7 to 8 June 1980
(3) Test - 19 May to 6 June 1980

c. Total number of working days:

(1) Training - 10
(2) Travel - 4 to 6
(3) Test - 15 (plus 4 spare days)

d. Number of hours to be worked each day per person: Approximately 10 hours for a total of 250 hours.

5. Preliminary Arrangements

a. All necessary personnel are to be nominated by name by 28 April 1980 and available for duty by 5 May 1980.

b. All equipment required for the training and testing is to be avialable for use at NEDU or Key West by 1 May 1980.

c. The following equipment will be provided from sources other than NEDU:

(1) Use of double-lock RCC at SPECFORSWIMSCHOOL Key West as upgraded by NEDU to NAVFAC certification standerds.

(2) Small boat support from NADC Key West, NCSC EOD DET and NAVSEA via NEDU.

(3) UBA MK 16 MOD 0 equipments, spares, and tool/test sets from NAVEODFAC.

(4) Workshop space in the vicinity of SPECFORSWIMSCHOOL and Key West EOD DET; NADC Bldg. No. 28 Pier Area Room 657, Lab. 624 Office 115, and Storage Room 880.

(5) Miscellaneous items for conducting the planned dives are to be ready by 28 May 1980 (e.g. depth gauges, descending lines, buddy lines, swim floats, MK 4 life preservers, etc.).

(6) The gas transfer system designed for use with the MK 16 will be provided by NSWC/DL to NEDU by 2 May for use during this test. NEDU will also provide commercially available Haskell booster pumps for backup use.

(7) PRC and mating rings for double-lock RCC as at present held by NEDU on loan from NSWC/DL.

## 6. Test Procedures

a. Test Criteria (for this test only)(thresholds quoted only).

(1) Maximum operating depth - 150 FSW.

(2) Maximum bottom time - As per PPO2 0.7 tables, total dive time not to exceed 4 hours.

(3) Operating temperature range - 29°F to 90°F.

(4) Reliability - (R).

(a) Life Support Functions - R/duration of mission: 0.975/10 minutes to 4 hours.

(b) Equipment - R/duration of mission: 0.95/10 minutes to 4 hours.

(5) Operational Availability - (Ao): 0.97

(6) Effectiveness - (E): 0.94

(7) Mission Success - (MS): 0.82

(8) MTTR - 1 hour.

b. Test Plan Program

(1) The pre-test training period will be used to evaluate the Training Course Plan and Learning Objectives. All dive time and procedures will count towards total evaluation of the UBA MK 16 MOD 0 TECHEVAL Objectives.

(2) The dive subjects from outside of NEDU will constitute the main group for training as all NEDU dive subjects have had various levels of training and experience in conjunction with other UBA MK 16 tests. The instruction will be from NAVSCOLEOD with NEDU assistance. The trainees will be split into 2 groups of 4 as only 4 MK 16 PPM's will be available. A shift system for diving will be utilized with combined classroom instruction.

(3) The test training program and test program are include as Enclosure (1).

c. Test Plan Procedures General

(1) Collation of all dive hours achieved, spares used and failures will be controlled by BMC(DV) J. H. BLOECHEL. The correct use and custody of all non-magnetic tools will also be udner BMC(DV) J. J. BLOECHEL. It cannot be overstressed that the MK 16 MOD 0 is an EOD diving equipment

and as such strict non-magnetic procedures must be observed. Additionally BMC(DV) J. H. BLOECHEL will be responsible for ensuring that divers carry out correct procedures with the MK 4 LIfe Preservers.

(2) Each diver is to prepare his own diving set and equipment in accordance with the appropriate manuals. On completion of each dive, post-dive procedures are to be completed prior to the equipment being turned over to the next dive subject. Failure to comply with this procedure will invalidate the collation of MTBF and MTTR hours.

(3) The specific dive procedures and decompression tables to be used during TECHEVAL are included as enclosures (2) and (3) respectively.

d. Required Test Hours to meet the Reliability criteria.

(1) Life Support Components

| Failures | Hours |
|---|---|
| 0 | 460 |
| 1 | 748 |
| 2 | 960 |

(2) Mission Support

| Failures | Hours |
|---|---|
| 0 | 62 |
| 1 | 114 |
| 2 | 163 |
| 3 | 210 |
| 4 | 249 |
| 5 | 299 |
| 6 | 340 |
| 7 | 380 |
| 8 | 425 |
| 9 | 470 |
| 10 | 518 |

(3) A failure for life support components is a failure specified in the FMEA as "critical" or "catastrophic". A failure for mission support is a failure specified as a premature abort of a dive once the system has been checked out and determined available. i.e. A failure after pre-dive set up has been completed prior to embarking in the dive boat. A failure during pre-dive set up will be counted towards availability calculations.

7. Post Test Arrangements

a. NEDU will arrange for the return of all equipment to their respective custodians. All PPM's, tool/test equipment and spares are to

be returned to NAVEODFAC on completion of the test for magnetic cleanliness testing.

8. Personnel

| | |
|---|---|
| Test Director | - LCDR M. J. HARWOOD, RN |
| Dive Officers | - LCDR J. T. HARRISON, USN |
| | - LCDR J. W. ENNIS, USN |
| | - LT N. G. GARON, USN |
| Master Diver | - CPO(D) C. A. KIDMAN, RN |
| Dive Supervisors | - ENC(DV) M. L. ALEXANDER, USN |
| | - CPO(D) C. A. KIDMAN, RN |
| | - MMCS(DV) D. E. DODDS, USN |
| Medical Officer | - LT C. G. GRAY, MC, USN; until 28 Apr |
| | - CAPT W. H. SPAUR, MC, USN; from 28 Apr |
| Human Factors Engineer | - LTJG D. J. STYER, Sr. MSC, USN |
| MK 16 MOD 0 Dive Subjects | - MN1(DV) W. A. BRADFIELD, USN |
| | - ABH1(DV) R. S. CROWDER, USN |
| | - LT N. G. GARON, USN |
| | - CPO(D) B. J. FURNER, RAN |
| | - GMG1(DV) A. W. PAAUWE, USN |
| | - LCDR J. W. ENNIS, USN/ LCDR J. T. HARRISON, USN |
| | - UTCS(DV) J. J. BECKER, USN |
| | - HM1(DV) J. P. BLACKSHIRE, USN |
| | - MM2(DV) C. W. WENTZEL, USN* |
| | - CWO2 W. A. BRINDLE, USN* |
| Medical Corpsman | - HMCS(DV) T. G. HOLMES, USN; until 31 May |
| | - HMCS(DV) C. K. BLAIR, USN; from 30 May |
| Equipment Maintainer | - BMC(DV) J. H. BLOECHEL, USN |
| | - EMCS(DV) C. P. WILKINSON, USN |
| Boat Maintainer | - EMC(DV) C. W. CLACKLEY, USN |
| Standby Divers & Tenders | - LTJG D. J. STYER, Sr., MCS, USN |
| | - BM2(DV) D. L. HUGHES, Jr., USN**; until 31 May |
| | - EN1(DV) J. L. DAIGLE, USN; until 31 May |
| | - BT1(DV) L. P. SIEMIET, USN; until 31 May |
| | - MMCS(DV) D. E. DODDS, USN |
| | - EMCS(DV) C. P. WILKINSON, USN |
| | - CE1(DV) M. R. ANDERSON, USN; until 31 May |
| | - BM1(DV) J. E. DEARING, USN; from 30 May |
| | - ENC(DV) R. R. SHAMBERGER, USN; until 31 May |

NOTE: * indicates Advance Party to Key West and MISS swims.
** indicates Advance Party to Key West.

9. Safety Rules and Precautions

a. As promulgated by the U. S. Navy Diving Manual, UBA MK 15 O&M Manual, UBA MK 16 MOD 0 O&M Manual (DRAFT), Life Preserver MK 4 O&M Manual, PRC

O&M Manual (DRAFT) (Extracts in accordance with enclosure (4)), procedures in accordance with enclosures (2) and (5), and decompression tables in accordance with enclosure (3).

b. No diver is to carryout any diving for a period of at least 12 hours before or after each MK 16 dive.

c. On completion of any dive requiring decompression stops, the diver is to remain with the dive team until reaching the close proximity of the two lock RCC. He is to remain in company with his dive buddy and within 10 minutes of the RCC for a 2 hour period after surfacing.

d. A nutritious diet is important for the long and arduous dives. No alcohol is to be consumed within the 24 hours preceeding a dive.

e. Further guidance and instructions on all dive procedures will be in accordance with Enclosure (2), and these procedures will be exercised during the training period.

f. The PRC is to be available at the dive site throughout the test. Extracts from the PRC O&M Manual (DRAFT) as amended by NEDU are in accordance with enclosure (4). This extract is to be read by all the TECHEVAL team.

10. <u>Logistic Support Required</u>

a. Transportation - By commercial air to NEDU (for EOD personnel outside of Panama City). As arranged by NEDU Operations Officer from NEDU to Key West and return, except EOD personnel from outside Panama City who will return direct to parent commands by commercial air.

b. Boats - NADC - Swift boats.

- NCSC EOD Detachment - Boston Whaler, rubber boat.

- NAVSEA provided to NEDU Monarch 23 ft.

c. Accomodation, Workshops and Office Space - Overnight boarding as booked in advance by NEDU. Workshops, NADC Bldg. No. 28, Pier Area Room 657, Lab 624, Storage Room 880. Office, Room 115.

d. HP Sodasorb - 20 pails at NEDU, 100 pails at Key West (transportation from NEDU 9 May)(1 pail = 37 lbs.).

e. $O_2$ - 6 x 200 cuft. bottles from NADC; $O_2$ refilled by NADC.

11. <u>Funding Source</u>

a. NAVSEA Funding has been transferred to NEDU for this test.

12. Report Production

a. NEDU will produce the TECHEVAL report within 30 days of completion of the test.

13. Comments/Additional Information

## DAILY MK 16 MOD 0 TECHEVAL SCHEDULE

| | | |
|---|---|---|
| 5 MAY 1980<br>MONDAY | 0800 | Brief all MK 16 UBA TECHEVAL personnel in EDF Conference Room. |
| | 0900 | Commence classroom procedures for MK 16 UBA.<br>Conduct Instruction on MK 4 Life Preserver.<br>Only MK 16 divers required to attend. |
| 6 MAY 1980<br>TUESDAY | 0700 | 3-mile run. |
| | 0800 | MK 16 pre-dive procedures.<br><br>Conduct initial dive in OSF test pool.<br><br>Buoyancy adjustments, etc.<br>Emergency Procedure brief.<br>Conduct post dive procedures.<br><br>Split MK 16 divers into two dive teams. |
| 7 MAY 1980<br>WEDNESDAY | 0600 | 3-mile run. |
| | 0800 | Group AM conduct familiarization dives in test pool.<br><br>Group PM classroom.<br>MK 16 Emergency Procedures.<br>MK 16 Troubleshooting Procedures. |
| 8 MAY 1980<br>THURSDAY | 0600 | 3-mile run. |
| | 0800 | Group AM classroom.<br>MK 16 Emergency Procedures.<br>MK 16 Troubleshooting Procedures.<br><br>Group PM conduct familiarization dive in OSF test pool. Test Emergency Procedures. |
| 9 MAY 1980<br>FRIDAY | 0600 | 4-mile run. |
| | 0800 | Group AM conduct Emergency Procedure training in OSF test pool.<br><br>Group PM conduct training on portable recompression chamber lock-on procedures. |

Enclosure (1)

| | | |
|---|---|---|
| 12 MAY 1980<br>MONDAY | 0700 | 4-mile run. |
| | 0800 | Classroom: Open-water dive procedures.<br>Medical presentation. |
| | 1200 | Group PM open-water dive (40 FSW).<br>1000 yd. jackstay. |
| | | Group AM conduct training on portable recompression chamber lock-on procedures. |
| 13 MAY 1980<br>TUESDAY | 0700 | Group AM open-water dive (40 FSW).<br>1000 yd. jackstay. |
| | | Group PM open-water dive (40 FSW).<br>1000 yd. jackstay. |
| 14 MAY 1980<br>WEDNESDAY | 0700 | Group AM open-water dive (40 FSW).<br>Decompression procedures. |
| | | Group PM open-water dive (40 FSW).<br>Decompression procedures. |
| 15 MAY 1980<br>THURSDAY | 0700 | 4-mile run. |
| | 0800 | Dive procedure debrief.<br>Key West update brief.<br>Gear pack-out. |
| 16 MAY 1980<br>FRIDAY | 0800 | Vehicles depart enroute Key West, FL |
| 17 MAY 1980<br>SATURDAY | 0945 | Remaining personnel depart enroute Key West via airlines. |
| | 1400 | Arrive Key West. |
| 18 MAY 1980<br>SUNDAY | 1200 | Vehicles arrive Key West.<br>Unload gear/equipment and prepare for dive scenario. |
| 19 MAY 1980<br>MONDAY | 0700 | Conduct Emergency Drills/Procedures for all dive scenarios. |
| | | Conduct portable recompression lock-on procedures. |
| | 1200 | Commence MK 16 UBA TECHEVAL. |
| | | Underway from pier. |

| | | |
|---|---|---|
| | 1300 | On station. Commence Dive (40 FSW/2 HR). |
| | 1700 | Depart dive site. |
| | 1800 | Return to pier. Conduct post-dive procedures. |
| 20 MAY 1980 TUESDAY | 0700 | Underway from pier. |
| | 0800 | On station. Commence Dive (40 FSW/2 HR). |
| | 1200 | Depart dive site. |
| | 1300 | Return to pier. Conduct post-dive procedures. |
| | 1400 | Underway from pier. |
| | 1500 | On station. Commence Dive (40 FSW/2 HR). |
| | 1900 | Depart dive site. |
| | 2000 | Return to pier. Conduct post-dive procedures. |
| 21 May 1980 Wednesday | 0700 | Underway from pier. |
| | 0800 | On station. Commence Dive (40 FSW/4 HR). |
| | 1200 | Depart dive site. |
| | 1300 | Return to pier. Conduct post-dive procedures |
| | 1400 | Underway from pier. |
| | 1500 | On station. Commence Dive (40 FSW/4 HR). |
| 22 May 1980 THURSDAY | 0700 | Underway from pier. |
| | 0800 | On station. Commence Dive (40 FSW/4 HR) |
| | 1200 | Depart dive site. |
| | 1300 | Return to pier. Conduct post-dive procedures. |
| | 1400 | Underway from pier. |
| | 1500 | On station. Commence Dive (40 FSW/4 HR). |
| | 1900 | Depart dive site. |

Enclosure (1)

| | | |
|---|---|---|
| | 2200 | Return to pier. Conduct post-dive procedures. |
| 23 May 1980<br>FRIDAY | 0700 | Underway from pier. |
| | 0800 | On station. Commence Dive (40 FSW/4 HR). |
| | 1200 | Depart dive site. |
| | 1300 | Return to pier. Conduct post-dive procedures. |
| | 1400 | Underway from pier. |
| | 1500 | On station. Commence Dive (40 FSW/4 HR). |
| | 1900 | Depart dive site. |
| | 2000 | Return to pier. Conduct post-dive procedures. |
| 24 May 1980<br>SATURDAY | | Gear maintenance and equipment upkeep. |
| 25 May 1980<br>SUNDAY | | Non-dive day. |
| 26 May 1980<br>MONDAY | 0700 | Underway from pier. |
| | 0800 | On station. Commence Dive (40 FSW/4 HR). |
| | 1200 | depart dive site. |
| | 1300 | Return to pier. Conduct post-dive procedures. |
| | 1400 | Underway from pier. |
| | 1500 | On station. Commence Dive (40 FSW/4 HR). |
| | 1900 | Depart dive site. |
| | 2000 | Return to pier. Conduct post-dive procedures. |
| 27 May 1980<br>TUESDAY | 0700 | Underway from pier. |
| | 0800 | On station. Commence Dive (60 FSW/180 MIN). |
| | 1200 | Depart dive site. |
| | 1300 | Return to pier. Conduct post-dive procedures. |

Enclosure (1)

| | | |
|---|---|---|
| | 1400 | Underway from pier. |
| | 1500 | On station. Commence Dive (60 FSW/180 MIN). |
| | 1900 | Depart dive site. |
| | 2000 | Return to pier. Conduct post-dive procedures. |
| 28 May 1980 WEDNESDAY | 0700 | Underway from pier. |
| | 0800 | On station. Commence Dive (60 FSW/180 MIN). |
| | 1200 | Depart dive site. |
| | 1300 | Return to pier. Conduct post-dive procedures. |
| | 1400 | Underway from pier. |
| | 1500 | On station. Commence Dive (60 FSW/180 MIN). |
| | 1900 | Depart dive site. |
| | 2000 | Return to pier. Conduct post-dive procedures. |
| 29 May 1980 THURSDAY | 0700 | Underway from pier. |
| | 0800 | On station. Commence Dive (90 FSW/60 MIN). |
| | 1200 | Depart dive site. |
| | 1300 | Return to pier. Conduct post-dive procedures. |
| | 1400 | Underway from pier. |
| | 1500 | On station. Commence Dive (90 FSW/60 MIN). |
| | 1900 | Depart dive site. |
| | 2000 | Return to pier. Conduct post-dive procedures. |
| 31 May 1980 SATURDAY | | Gear maintenance and equipment up-keep. |
| 1 June 1980 SUNDAY | | Non-dive day. |
| 2 June 1980 MONDAY | 0700 | Underway from pier. |

| | | |
|---|---|---|
| | 0800 | On station. Commence Dive (120 FSW/20 MIN). |
| | 1700 | Depart dive site. |
| | 1800 | Return to pier. Conduct post-dive procedures. |
| 3 June 1980 TUESDAY | 0700 | Underway from pier. |
| | 0800 | On station. Commence Dive (120 FSW/20 MIN). |
| | 1700 | Depart dive site. |
| | 1800 | Return to pier. Conduct post-dive procedures. |
| 4 June 1980 WEDNESDAY | 0700 | Underway from pier. |
| | 0800 | On station. Commence Dive (150 FSW/15 MIN). |
| | 1700 | Depart dive site. |
| | 1800 | Return to pier. Conduct post-dive procedures. |
| 5 June 1980 THURSDAY | 0700 | Underway from pier. |
| | 0800 | On station. Commence Dive (150 FSW/15 MIN). |
| | 1700 | Depart dive site. |
| | 1800 | Return to pier. Conduct post-dive procedures. |
| 6 June 1980 FRIDAY | 0700 | Underway from pier. |
| | 0800 | On station. Commence Dive (40 FSW/4 HR) |
| | 1700 | Depart dive site. |
| | 1800 | Return to pier. Conduct post-dive procedures. |

Enclosure (1)

TEST PROCEDURE FOR MK 16 MOD 0 TECHEVAL

1. Dive Procedures. The following depths and maximum bottom times will be used throughout the test series. All normal decompression will be in accordance with the U.S. Navy 0.7 ATA constant $PPO_2$ in $N_2$ tables (enclosure (3)). Emergency procedure decompression will be in accordance with enclosure (5).

| Depth (FSW) | Bottom Time (Minutes) | Total Ascent Time (Minutes) |
|---|---|---|
| 40 | 240 | 0::40 secs |
| 60 | 180 | 38::00 |
| 90 | 60 | 42::30 secs |
| 120 | 15 | 26::00 |
| 150 | 15 | 39::30 secs |

2. Specific Dive Procedures at Key West

a. Dive Days #1 and #2.

(1) On dive days #1 and #2 the dive depth will be 40 FSW with a 120 minute bottom time (bottom time starts when the divers leave the surface). After pre-dive set ups two (2) sets of divers will dress up in wet suits and MK IV life jackets. One diver in each set will be bodily marked by a small float which will be tied off at 40 FSW (the divers will also wear depth gauges). Both divers will be attached with a buddy line.

(2) A light jackstay of 1,000 yds will have been layed and both sets of divers will follow this line. If for some reason the jackstay cannot be used both sets of divers will be given a swim board with compass.

(3) When putting the divers in the water, the diver with the float line will enter the water first, the 2nd diver will enter the water and clip up his buddy line. Both divers will hold the clips above the water so that the Dive Supervisor can see that they are properly joined. Both divers will then check each other for leaks, if there are no leaks the Dive Supervisor will then tell the divers to leave the surface. Two (2) minutes before the divers are to come to the surface, the dive safety boat will recover the float line and give the signal of 3 pulls (standby to come up), the diver will pass this signal to his dive buddy. The signal of 4 pulls (come up) will then be given and both divers will surface together. The diver with the float line will give 1 pull (left bottom) when both divers leave the bottom.

(4) Both divers will come directly to the surface (at 60 FSW per min) as no decompression will be required.

b. Div Days #3 thru #6.

(1) On dive days #3 thru #6 the depth will be 40 FSW but the bottom time will increase to 240 minutes. The dive procedure will be the same as for dive days #1 and #2. No decompression will be required.

c. Dive Days #7 and #8.

(1) On dive days #7 and #8 the dive depth will be 60 FSW with a 180 minute bottom time. The pre-dive procedures and diver dress out will be the same as previous dive days. After the divers have been put in the water and checked for leaks, they will leave the surface as directed by the Dive Supervisor. It must be made clear to the divers that after 30 minutes at this depth they will require decompression. Procedures for aborting the dive after this time will be covered in this test procedure under Safety Rules and Precautions (enclosure (5)).

(2) If the dive proceeds as scheduled five (5) minutes before the divers are due to come up the safety boat will recover the float line and give 3 pulls (standby to come up). The diver with the float line will pass the signal to his buddy. The dive safety boat will then slide the lazy shot down the float line to 10 FSW below the divers first stop depth. When it is in position the signal of 4 pulls - 2 pulls (come up to your lazy shot) will be given; the diver with the float line must remember to give 1 pull (left bottom) when both divers have left bottom.

(3) Both divers will slowly follow their float line up until they reach the lazy shot (ascent rate 60 FSW per min), on reaching the lazy shot the signal of 1 pull (at lazy shot) will be given by the diver. The float line will be recovered by the safety boat. The Dive Supervisor will check markings on both the float line and lazy shot line and then bring the divers to their first stop. Decompression will be completely run by the safety boat, and the divers will follow the lazy shot when it moves upward to the next decompression stop. The diver without the float line must ensure that he stays at the same depth as the lazy shot.

(4) On completion of the last stop the divers will be brought to the surface.

d. Dive Days #9 and #10.

(1) On dive days #9 and #10 the depth will be 90 FSW with a 60 minute bottom time. These dives will be run exactly the same as the procedures for the 60 FSW dives except the stoppage depths will be deeper.

e. Dive Days #11 and #12.

(1) On dive days #11 and #12 the depth will be 120 FSW with a 15 minute bottom time. These dives will be conducted from a diving platform.

(2) A descent line with a 120 lb sinker will be lower over the side and placed on the seabed. Only two (2) divers will be put into the water at a time at this depth. Each diver will have an individual life line. Both divers will enter the water and check each other for leaks, and when directed by the Dive Supervisor they will leave the surface together. The divers will stay together during descent. On arrival on the bottom the signal 1 Pull will be given by both divers, the lazy shot will then be lowered to 10 FSW below the first decompression stop.

(3) Three (3) minutes before the divers are due to leave the bottom the signal 3 pulls (standby to come up) will be given to both divers.

(4) The divers will then be given 4 pulls - 2 pulls (come up to your lazy shot). Both divers will give 1 pull when leaving the bottom, both divers will remain together during ascent to lazy shot. On arrival at lazy shot both divers will give 1 pull. The lazy shot will then be hoisted to the first stop and decompression will commence on arrival at first stop.

f. Dive Days #13 and #14.

(1) On dive days #13 and #14 the depth will be 150 FSW with a 15 minute bottom time. Procedures will be the same as for the 120 FSW dive.

2. <u>Personnel</u>. The following is a list of the minimum personnel required.

DIVING OFFICER

NO. 1 SAFETY BOAT — NO. 2 SAFETY BOAT

| NO. 1 SAFETY BOAT | | NO. 2 SAFETY BOAT | |
|---|---|---|---|
| DIVE SUPERVISOR | | DIVE SUPERVISOR | |
| 2 DIVERS | 1 STANDBY<br>1 ATTENDANT | 2 DIVERS | 1 STANDBY<br>1 ATTENDANT |

Fast Recovery Boat (for treatment or casualties).

1 Coxswain
1 Medical Officer or Hospital Corpsman Diving Technician.

Enclosure (2)

Chamber (ashore)

1 Medical Attendant of Diving Medical Officer
1 Chamber Operator

For the 120 FSW and 150 FSW dives personnel can be cut to 1 Supervisor, 1 Standby diver and 1 Attendant.

3. Marked Lines and Accessories

| Number Required | Length (FSW) | Description |
|---|---|---|
| 2 | 250 | Descent lines |
| 2 | 120 | Lazy shot lines |
| 2 | 180 | Life lines |
| 2 | 100 | Swim lines |
| 2 | 180 | Lost diver markers |
| 11 | 90 | Jackstay risers |
| 11 | 60 | Jackstay risers |
| 11 | 40 | Jackstay risers |
| 2 | 140 | Anchor lines |
| 1 | 1,000 yd | Light jackstay |

| | |
|---|---|
| 4 | Large Floats |
| 2 | Sets of buddy lines |
| 2 | 120 lb sinkers |
| 20 | 30 lb sinkers |
| 2 | Danforth anchors |
| 15 | Small floats |

All lines have the capability of being marked with floats if required.

4 Line Pull Signals

a. From Tender to Diver

1 Pull - "Are you alright?"
When diver is descending, one pull means "Stop."

2 Pulls - "Go down."
During ascent, 2 pulls mean you have come up to far, go back down until we stop you.

3 Pulls - "Standby to come up."
If at the end of a search line, the diver returns to his descent line.

4 Pulls - "Come up."

4 Pulls - 2 Pulls - "Come up to your lazy shot."

Enclosure (2)

b. From Diver to Tender

1 Pull - "I am alright" or "I am on the bottom."
"I am at my lazy shot" or "I am at my descent line."

2 Pulls - "Lower" or "Give me slack."

3 Pulls - "Take up my slack."

4 Pulls - "I want to come up."

c. Emergency Signals

2-2-2 Pulls - "I need the assistance of the standby diver."

3-3-3 Pulls - "I am fouled but can clear myself."

4-4-4 Pulls - "Emergency! Recover me immediately."
(This signal does not require answering)

5. Safety Rules and Precautions. The safety of divers is of the upmost priority during this test series. The following rules and precautions must be adhered to.

a. Aborting a Dive. (Diver feels fatigued but is not in an emergency situation.) Diver will give one pull to call attention, the safety boat will then recover the marker and answer the signal. The diver will then give 4 pulls (I want to come up) before the dive safety boat answers, the Dive Supervisor will check the divers time and if decompression is required the lazy shot will be lowered and the signal of 4 pulls - 2 pulls will be given to the diver. If no decompression is required the signal will be answered by 4 pulls (come up) and the divers will return to the surface.

b. Divers Become Unbuddied and Lose Each Other. Both divers in the event of losing sight of each other will surface immediately. Refer to enclosure (5) for handling of divers after surfacing.

c. Diver's UBA Becomes Defective at Depth

(1) Complete loss of gas: At dive depths of 120 FSW and 150 FSW a SCUBA bottle filled with air will be stopped on the descent line approximately 10 FSW from the bottom. Procedure for the use of the SCUBA bottle will be in accordance with enclosure (5).

(2) $O_2$ add valve remains open - secure $O_2$ bottle and return to the surface using MK 16 Mod 0 emergency procedure for this failure mode.

d. A helo will be available for emergency use if the situation requires rapid reaction that cannot be carried out by one of the dive boats.

e. A standby diver on SCUBA will be in the immediate vicinity during jackstay swims, one for each set of divers.

f. A standby diver in a MK-15 will be available on immediate notice during 120 FSW and 150 FSW dives.

g. If for some reason the dive marker float becomes detached from a dive pair they will be called up by either Hydrophone or a sound signal.

Enclosure (2)

DECOMPRESSION TABLES

0.7 ATA CONSTANT $PPO_2$ IN $N_2$

Enclosure (3)

# DECOMPRESSION TABLES

## 0.7 ATA CONSTANT $PPO_2$ IN $N_2$

| DEPTH (FSW) | BOTTOM TIME (MINUTES) | TIME TO FIRST STOP (MIN: SEC) | DECOMPRESSION STOPS (FSW) 90 | 80 | 70 | 60 | 50 | 40 | 30 | 20 | 10 | TOTAL ASCENT (MIN: SEC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 | 360 | 0:40 | NO DECOMPRESSION | | | | | | | | | 0:40 |
| 50 | 30 | 0:40 | | | | | | | | | 2 | 2:50 |
| | 60 | 0:40 | | | | | | | | | 5 | 5:50 |
| | 90 | 0:40 | | | | | | | | | 7 | 7:50 |
| | 120 | 0:40 | | | | | | | | | 10 | 10:50 |
| | 150 | 0:40 | | | | | | | | | 12 | 12:50 |
| | 180 | 0:40 | | | | | | | | | 14 | 14:50 |
| | 210 | 0:40 | | | | | | | | | 16 | 16:50 |
| | 240 | 0:40 | | | | | | | | | 20 | 20:50 |
| | 270 | 0:40 | | | | | | | | | 23 | 23:50 |
| | 300 | 0:40 | | | | | | | | | 25 | 25:50 |
| | 330 | 0:40 | | | | | | | | | 27 | 27:50 |
| 60 | 30 | 0:40 | | | | | | | | 1 | 5 | 7:00 |
| | 60 | 0:40 | | | | | | | | 3 | 9 | 13:00 |
| | 90 | 0:40 | | | | | | | | 4 | 14 | 19:00 |
| | 120 | 0:40 | | | | | | | | 5 | 19 | 25:00 |
| | 150 | 0:40 | | | | | | | | 7 | 21 | 29:00 |
| | 180 | 0:40 | | | | | | | | 9 | 28 | 38:00 |
| | 210 | 0:40 | | | | | | | | 10 | 33 | 44:00 |
| | 240 | 0:40 | | | | | | | | 11 | 37 | 48:00 |
| | 270 | 0:40 | | | | | | | | 11 | 44 | 55:00 |
| | 300 | 0:40 | | | | | | | | 14 | 48 | 63:00 |

# DECOMPRESSION TABLES

## 0.7 ATA CONSTANT $PPO_2$ IN $N_2$

| DEPTH (FSW) | BOTTOM TIME (MINUTES) | TIME TO FIRST STOP (MIN: SEC) | DECOMPRESSION STOPS (FSW) 90 | 80 | 70 | 60 | 50 | 40 | 30 | 20 | 10 | TOTAL ASCENT (MIN: SEC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | 20 | 0:50 | | | | | | | | 2 | 4 | 7:10 |
| | 40 | 0:40 | | | | | | | 1 | 4 | 9 | 15:10 |
| | 60 | 0:40 | | | | | | | 1 | 7 | 12 | 21:10 |
| | 80 | 0:40 | | | | | | | 2 | 9 | 17 | 29:10 |
| | 100 | 0:40 | | | | | | | 2 | 11 | 20 | 34:10 |
| | 120 | 0:40 | | | | | | | 3 | 14 | 24 | 42:10 |
| | 140 | 0:40 | | | | | | | 3 | 16 | 30 | 50:10 |
| | 160 | 0:40 | | | | | | | 3 | 18 | 35 | 57:10 |
| | 170 | 0:40 | | | | | | | 4 | 19 | 37 | 61:10 |
| 80 | 10 | 1:00 | | | | | | | | 2 | 3 | 6:20 |
| | 20 | 0:50 | | | | | | | 2 | 3 | 5 | 11:20 |
| | 30 | 0:50 | | | | | | | 2 | 5 | 8 | 16:20 |
| | 40 | 0:50 | | | | | | | 4 | 6 | 10 | 21:20 |
| | 50 | 0:50 | | | | | | | 4 | 8 | 12 | 25:20 |
| | 60 | 0:50 | | | | | | | 5 | 9 | 16 | 31:20 |
| | 70 | 0:40 | | | | | | 1 | 6 | 9 | 20 | 37:20 |
| | 80 | 0:40 | | | | | | 1 | 7 | 12 | 20 | 41:40 |
| | 90 | 0:40 | | | | | | 1 | 8 | 14 | 20 | 44:40 |
| 90 | 10 | 1:00 | | | | | | | 1 | 2 | 3 | 7:30 |
| | 20 | 0:50 | | | | | | 1 | 2 | 4 | 6 | 14:30 |
| | 30 | 0:50 | | | | | | 2 | 4 | 5 | 10 | 22:30 |
| | 40 | 0:50 | | | | | | 2 | 5 | 8 | 12 | 28:30 |
| | 50 | 0:50 | | | | | | 3 | 6 | 9 | 17 | 36:30 |
| | 60 | 0:50 | | | | | | 4 | 8 | 9 | 20 | 42:30 |
| | 70 | 0:50 | | | | | | 4 | 9 | 13 | 20 | 47:30 |

# DECOMPRESSION TABLES

## 0.7 ATA CONSTANT $PPO_2$ IN $N_2$

| DEPTH (FSW) | BOTTOM TIME (MINUTES) | TIME TO FIRST STOP (MIN: SEC) | DECOMPRESSION STOPS (FSW) 90 | 80 | 70 | 60 | 50 | 40 | 30 | 20 | 10 | TOTAL ASCENT (MIN: SEC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 10 | 1:10 | | | | | | | 2 | 2 | 3 | 8:40 |
| | 20 | 1:00 | | | | | | 2 | 2 | 5 | 7 | 17:40 |
| | 30 | 0:50 | | | | | 1 | 3 | 4 | 7 | 10 | 26:40 |
| | 40 | 0:50 | | | | | 1 | 4 | 5 | 9 | 15 | 35:40 |
| | 50 | 0:50 | | | | | 2 | 4 | 8 | 9 | 20 | 44:40 |
| | 55 | 0:50 | | | | | 2 | 4 | 9 | 11 | 20 | 47:40 |
| 110 | 10 | 1:10 | | | | | | 1 | 2 | 2 | 4 | 11:50 |
| | 20 | 1:00 | | | | | 2 | 2 | 4 | 5 | 9 | 23:50 |
| | 30 | 0:50 | | | | 1 | 2 | 4 | 4 | 8 | 12 | 32:50 |
| | 40 | 0:50 | | | | 1 | 3 | 4 | 7 | 10 | 18 | 44:50 |
| | 45 | 0:50 | | | | 1 | 4 | 4 | 9 | 10 | 20 | 49:50 |
| 120 | 10 | 1:20 | | | | | | 2 | 2 | 2 | 5 | 13:00 |
| | 20 | 1:00 | | | | 1 | 2 | 2 | 4 | 5 | 10 | 26:00 |
| | 30 | 1:00 | | | | 2 | 3 | 4 | 6 | 9 | 15 | 40:00 |
| | 40 | 1:00 | | | | 3 | 4 | 5 | 9 | 10 | 20 | 53:00 |
| 130 | 10 | 1:20 | | | | | 1 | 2 | 2 | 3 | 5 | 17:10 |
| | 20 | 1:00 | | | 1 | 2 | 2 | 4 | 4 | 7 | 10 | 31:10 |
| | 30 | 1:00 | | | 2 | 2 | 4 | 4 | 8 | 9 | 17 | 47:10 |
| | 35 | 1:00 | | | 2 | 3 | 4 | 5 | 9 | 10 | 20 | 55:10 |
| 140 | 10 | 1:30 | | | | | 2 | 2 | 2 | 4 | 5 | 17:20 |
| | 20 | 1:10 | | | 2 | 2 | 2 | 4 | 4 | 8 | 11 | 35:20 |
| | 30 | 1:00 | | 1 | 2 | 3 | 4 | 5 | 9 | 9 | 20 | 55:20 |

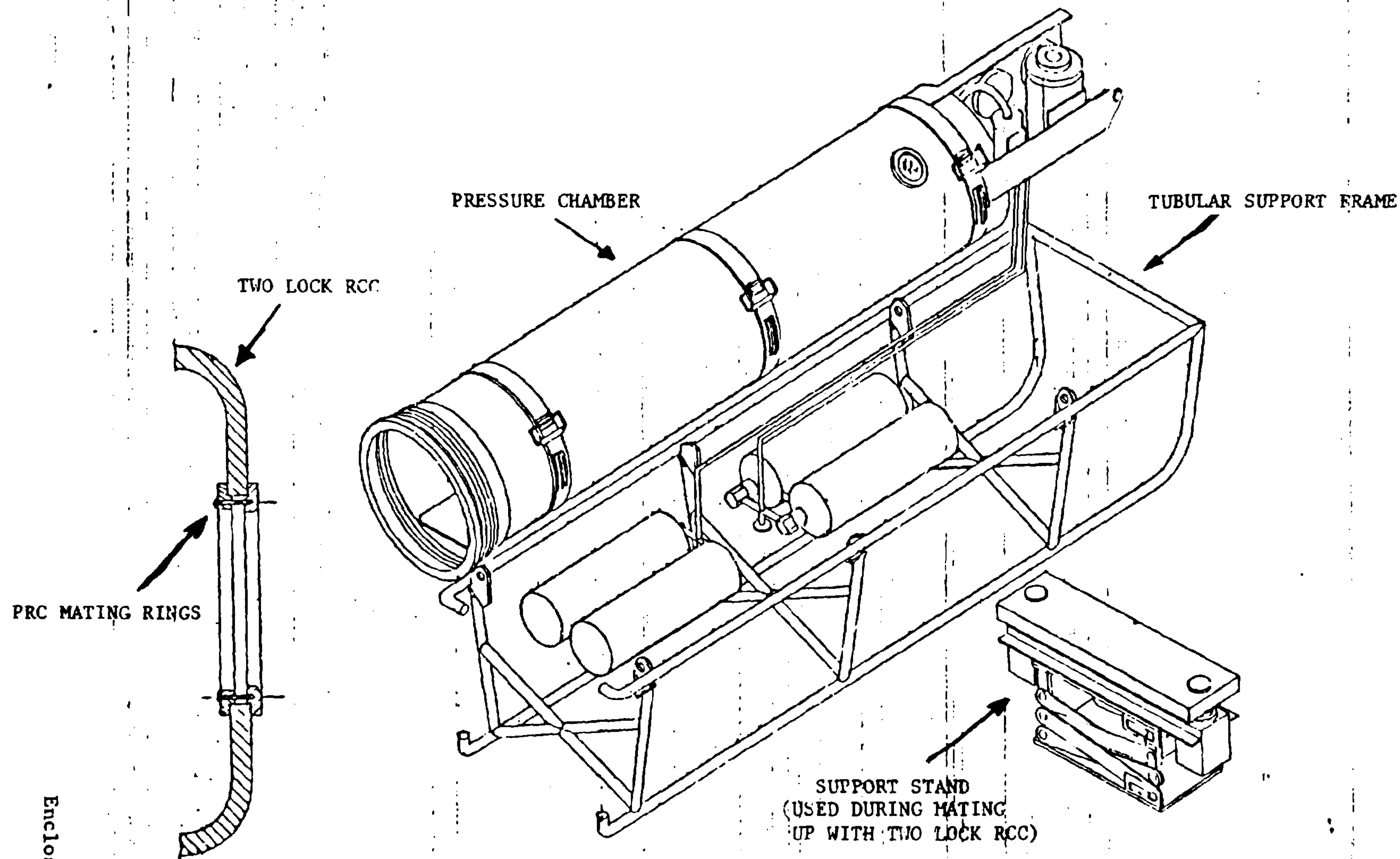
# DECOMPRESSION TABLES

## 0.7 ATA CONSTANT $PPO_2$ IN $N_2$

| DEPTH (FSW) | BOTTOM TIME (MINUTES) | TIME TO FIRST STOP (MIN: SEC) | DECOMPRESSION STOPS (FSW) 90 | 80 | 70 | 60 | 50 | 40 | 30 | 20 | 10 | TOTAL ASCENT (MIN: SEC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | 10 | 1:30 | | | | 1 | 2 | 2 | 2 | 4 | 5 | 18:30 |
| | 20 | 1:10 | | 1 | 2 | 2 | 3 | 4 | 4 | 9 | 12 | 39:30 |
| | 30 | 1:00 | 1 | 2 | 2 | 4 | 4 | 6 | 9 | 11 | 20 | 61:30 |

EXTRACTS FROM THE DRAFT PRC MANUAL

Enclosure (4)




PORTABLE RECOMPRESSION CHAMBER

CHAPTER 1

GENERAL INFORMATION

## 1.0 INTRODUCTION

The Portable Recompression Chamber (PRC) is a one man hyperbaric system designed for providing immediate recompression treatment to divers suffering from decompression sickness or gas embolism. It is to be deployed to remote dive sites where recompression treatment can be administered within five minutes to a diver showing symptoms of these pressure-related injuries. The PRC can also serve as a means of transporting a stricken diver, while undergoing recompression treatment, to a larger hyperbaric facility for more definitive treatment and care.

The PRC is not intended as a substitute for double-lock recompression chambers. The PRC serves as an emergency chamber at sites where double-lock chambers are not immediately available.

## 1.1 SCOPE OF MANUAL

This manual describes the purpose, limitations, treatment procedures, operation, planning, maintenance and components of the U.S. Navy's Portable Recompression Chamber. The certification procedures for personnel are included in the Personnel Qualification Schedule (PQS).

## 1.2 DESCRIPTION

The PRC is 106 inches long and weighs 350 pounds. It consists of a one-man single-lock pressure chamber with recirculating, semi-closed-circuit

life support system and a communication system. The chamber and piping are mounted on a tubular support frame that serves as a stand and as a means to facilitate transportation. A series of quick release pins hold the chamber to the support frame. By removing the support frame, the PRC can be passed through a circular opening of 23 3/4 inches in diameter such as the torpedo hatch of a submarine. The PRC has a design working pressure of 73.5 psig (165 Feet of Sea Water - FSW); however, the maximum normal operating pressure is 44.5 psig to effect treatment at depths equivalent to 100 FSW.

The PRC can be operated in an open-circuit or semi-closed circuit mode of operation. The open-circuit mode is a single-pass system in which two (2) actual cubic feet per minute* (acfm) of fresh air are metered into the chamber, ducted to the patient, and then vented. The semi-closed circuit mode uses approximately .5 standard cubic feet per minute (scfm) of incoming fresh air to recirculate the breathed air, through a $CO_2$ scrubber, by means of an air ejector that is designed to recirculate at least two (2) acfm of air to the patient at any operating depth. For both modes, compressed air is supplied from twin SCUBA tanks.

A mating adapter system is included with each PRC. This adapter system is used to mate the PRC to a Navy double lock aluminum recompression chamber such that a patient can be transferred under pressure without interrupting the treatment schedule.

*acfm = scfm x depth in atmospheres

CHAPTER 2

OPERATIONS

## 2.1 INTRODUCTION

This chapter provides condensed information for the diagnosis, recompression treatment, and transportation of decompression sickness and gas embolization casualties. The U.S. Navy Diving Manual, Volume I, contains more complete information. This chapter also provides detailed information for operational planning and operation of the PRC.

The PRC is intended to provide definitive initial treatment and may serve to transport the injured diver, while undergoing treatment, to a larger recompression chamber. A mating adapter system is included in order to effect transfer upon arrival at the treatment facility. An alternative surfacing and transfer procedure is provided. A rapid and well throught-out transportation plan is extremely important when the PRC is employed.

Treatment in the Portable Recompression Chamber is severely disadvantaged because of it being a small, single-lock, one-man system lacking oxygen treatment capability. The advantage of the PRC is its portability to remote dive sites for operations not supported by larger surface craft. The compromised treatment mode can only be overcome by immediate, on-site recompression treatment. If the PRC is not at the dive site, or if treatment is delayed more than minutes, a poor outcome can be expected. Therefore, the PRC should be positioned so that an injured diver can be brought to the chamber within 5 minutes of surfacing.

Because of lack of oxygen treatment and inability to gain access to the injured diver once pressurized, the usable treatment modes are limited and all diving accidents will be treated with the PRC Treatment Table (Table 2-1). Figure 2-1, "Diagnosis of Decompression Sickness and Gas Embolism" and Figure 2-2, "Treatment of Decompression Sickness and Gas Embolism" provide guidelines for management of diving casualties with the PRC.

2.2 <u>TREATMENT PROCEDURES</u>

Actions in each case, in the order of priority, usually are: first aid (assure clear airway, restore breathing, assure heart function, and stop massive bleeding); examination; diagnosis; and treatment in accordance with the PRC Treatment Table.

When a determination has been made that recompression treatment is required, the following step-by-step procedures will be followed:

a. Clean, disrobe, and dress the patient for the ambient temperature. Care must be taken not to introduce any materials into the PRC which would contaminate the atmosphere or cause a fire hazard.

b. Always place the patient in the PRC head first and secure with straps. The supine or prone position should be utilized as directed by the patient's condition at the time of recompression. For example, if vomiting is likely, the chest-down position is favored.

c. Always start treatment on the PRC Treatment Table for all cases of gas embolism and decompression sickness. Treatment tables longer than the PRC schedule <u>are not to be initiated</u> even if the patient is deteriorating.

d. Commence recompression as rapidly as possible. DO NOT DELAY TREATMENT BECAUSE OF A COMMUNICATION MALFUNCTION.

e. The PRC Table is to be completed and the patient removed from the PRC, even if relief is not complete or if there is recurrence during treatment.

f. At the end of the PRC Treatment Table, if transfer has not been effected, the patient must be removed, hydrated, encouraged to urinate, and re-evaluated. A repeat PRC Table then may be warranted in cases with residual symptoms. In addition, recurrence during treatment or following treatment may be treated with a repeat PRC Table.

g. Observe patient for 12 hours after treatment for recurrence of symptoms.

EMERGENCY CONSULTATION IS AVAILABLE ON 24 HOUR CALL AT THE NAVY EXPERIMENTAL DIVING UNIT, PANAMA CITY, FLORIDA 32407. TELEPHONE AUTOVON 436-4351 OR COMMERCIAL (904) 234-4351.

## 2.3 TRANSPORTATION

The patient is to be transported in the PRC, while undergoing treatment, to a larger treatment chamber only if transportation will not interfere with the proper administration of the Treatment Table. Conducting the PRC Table treatment has first priority. Transportation to a larger treatment chamber enables the casualty to be treated with the more effective Table 5 or 6 of the U.S. Navy Diving Manual, and allows retreatment on Table 5 or 6 if relief is not complete with the PRC Table.

Enclosure (4)

## 2.4 PATIENT

A patient may be transferred from the PRC to a larger treatment chamber by mating, by insertion, or by decompression, transfer and recompression. Insertion or mating are the preferred methods of transfer because depressurization is not required.

### 2.4.1 Mating

By utilizing the mating adapter system, (see paragraph 2-13) the PRC can be mated to the standard Navy aluminum double lock recompression chamber. After mating, compress or decompress, whichever is appropriate, to 60 FSW and transfer patient to the double lock chamber. Treat in accordance with Table 5 or 6.

### 2.4.2 Insertion

Tranfer by insertion requires that the treatment chamber be of sufficient size to accept the entire PRC and allow removal of the patient from the PRC. Once the PRC is inside the treatment chamber, compress the treatment chamber and compress or decompress the PRC, whichever is appropriate, to 60 FSW and transfer the patient. Treat in accordance with Table 5 or 6.

### 2.4.3 Decompression - Transfer - Recompression

If mating or insertion of the PRC is NOT possible, complete the 40 FSW stop in the PRC. Decompression and recompression procedures, as follows, are to be completed in <u>5 minutes or less</u>:

a. Surface no faster than 60 feet/minute.

b. Transfer patient to larger chamber.

c. Compress to 60 FSW in the larger chamber, breathing $O_2$ from the surface.

d. Treat with Table 5 or 6. A repeat treatment in accordance with Table 5 or 6 may be warranted in cases with residual symptoms.

## 2.5 USE OF PRC IN OMITTED DECOMPRESSION

Certain emergencies may interrupt or prevent specified decompression. Blow-up, exhausted air supply, bodily injury and similar situations constitute such emergencies. If the diver shows any signs of decompression sickness or gas embolism, immediate treatment using the PRC Table is essential. Even if the diver shows no symptoms of decompression sickness, omitted decompression must be made up in some manner to avert later difficulty.

The Surface Decompression Table Using Air may be used in the PRC, to make up omitted decompression, only if the emergency surface interval occurs at such a time that water stops are not required or have already been completed.

When the conditions which permit the use of the Surface Decompression Table Using Air are NOT fulfilled, the diver's decompression has been compromised. Special care must be taken to detect signs of decompression sickness, regardless of what action is initiated. The diver must be returned to pressure as soon as possible and the PRC Table completed. If the diver can be transported while undergoing the PRC Table and transferred to a double lock chamber, treatment may be completed using Table 5.

Enclosure (4)

## 2.6 OTHER USES OF THE PRC

The PRC is for immediate, emergency treatment of decompression sickness and gas embolism at diving sites where a Navy double lock recompression chamber is not available. The PRC also provides capability to transport the patient while he is undergoing recompression treatment.

The PRC is not to be used for surface decompression, pressure tests, or indoctrination dives.

The PRC may be used for the training and certification of the PRC chamber operators. A 60 FSW for 10 min with stops of 5 min at 40, 30, 20, and 10 ft may be used for training and familiarization purposes.

The Diving Manual requirement to have a chamber on site for surface-supplied air or helium-oxygen diving deeper than 170 feet cannot be fulfilled by the PRC. The PRC does meet the requirements for a chamber on site for scuba and mixed gas scuba diving.

## 2.7 ABORT PROCEDURES

In an emergency, the PRC Table may be aborted during compression or during the initial 25 minutes of bottom time by using the no-decompression tables of the Standard Air Tables. An emergency abort may worsen decompression sickness. Recompression and PRC Table treatment should follow immediately if the cause of the emergency can be corrected.

Figure 2-1, "Diagnosis of Decompression Sickness and Gas Embolism" and Figure 2-2, "Procedures for Treatment of Decompression Sickness and Gas Embolism" will be helpful in the diagnosis of and treatment of patients.

2.8 THERMAL CONSIDERATIONS

Under high environmental temperature conditions, or when placed in direct sunlight, the PRC is subject to sufficient heat build-up to result in heat stress to the diver. In addition, metabolic heat produced by the diver's body is confined to the chamber, and water vapor from diver sweat production causes the relative humidity within the PRC to quickly approach 100%. Air flow within the chamber is slight, and this impairs heat loss as well. Heat build-up, which begins with compression and may continue for the entire six-hour PRC Table, causes increasing stress on the diver hour by hour. Physiological changes from heat stress, including dehydration and low blood pressure, may interfere with successful treatment of decompression sickness. For these reasons, the PRC cannot be utilized at ambient shaded temperatures of greater than 85°F (29.5°C) for six hours or 95°F (35°C) for two hours.

Normally, most heat loss occurs at the skin surface where heat is transferred from deep body tissues by the flow of blood. As the heat content of the body increases, surface skin blood vessel dilation occurs, thereby increasing blood flow to the skin and allowing heat loss by convection and radiation. In addition, water is deposited at the skin surface by increased sweat gland activity and diffusion through the skin. Evaporation of this water results in a large increase in the rate of cooling. Although the body can produce sweat at a high rate, evaporative heat loss is limited by skin temperature; the difference or gradient between water vapor pressure at the skin and in surrounding air; and movement of air across the body surface.

Enclosure (4)

When the temperature within the PRC is high, evaporative heat loss can not compensate for the heat load. This is attributable to failure to achieve a high perspiration rate, or to failure to achieve a high evaporative rate. Even when the perspiration rate is high, conditions of high relative humidity and low ventilation in the PRC seriously limit cooling by evaporation. In addition, the maximum attainable perspiration rate of the average person is about 30 ml or 2 ounces per minute. However, at these rates of sweating, even with adequate consumption of salt and water, the sweating mechanism fatigues in three to four hours, resulting in a significant decrease in the rate of perspiration. This maximum rate of sweating can also be limited by incomplete acclimatization of the individual to the hot environment.

Failure to completely replace water lost by sweating may lead to elevation of body temperature and dehydration. Overheating of the diver initially causes generalized symptoms which may be confused with symptoms caused by the diving accident, and may not be recognized as being related to the effects of heat. Presenting symptoms of <u>heat exhaustion</u> may include headache, dizziness, fainting, confusion, incoordination, visual disturbances, vomiting, and profound weakness. The skin is usually moist and clammy, and the pulse is weak and rapid. Progression of symptoms with failure of temperature regulation results in <u>heat stroke</u>, which is characterized by increased body temperature, delerium, and hot, dry, flushed skin with diminished or absent sweating. This is associated with a high mortality rate.

Successful treatment of decompression sickness depends upon adequate hydration. Thirst is unreliable as an indicator of the water intake

necessary to compensate for heavy sweating, and isolation of the patient within the PRC makes it difficult to assess his overall fluid balance. Because of these factors, warm weather PRC operations are limited by the guidelines outlined in Section 2.8.1.

2.8.1 SUMMARY OF GUIDELINES FOR WARM WEATHER PRC OPERATIONS.

| Ambient Shaded Temperature | Predicted Internal PRC Temperature | Maximum Tolerance Time | Operational Guidelines |
|---|---|---|---|
| Over 95°F (35°C) | Over 104°F (40°C) | Intolerable | A |
| 85-95°F (29.5-35°C) | 94-104°F (34.4-40°C) | 2 hours | B,C,D,E,G |
| 76-85°F (24.4-29.5°C) | 85-94°F (29.5-34.4°C) | 6 hours | C,D,E, |
| Under 76°F (24.4°C) | Under 85°F (29.5°C) | Over 8 hours | C ,D,F |

Warm weather operational guidelines:

A - Use of the PRC at ambient shaded temperatures above 95°F (35°C) is prohibited.

B - Do not employ the PRC at ambient shaded temperatures above 85°F (29.5°C) unless temperature control or transfer to a larger chamber can be accomplished within 2 hours.

C - Always shade the PRC from direct sunlight.

D - The use of vents as set forth in 2.10.8.1 of this manual is highly recommended when inside temperature aproaches 85°F (29.5°C).

E - Assure that the patient drinks 1000 ml (1 quart) of water hourly when the temperature is above 85°F (29.5°C) in the chamber.

F. Assure that the patient drinks 500 ml (1 pint) of water hourly when the temperature is less than 85°F (29.5°C) in the chamber.

G - If the internal PRC temperature exceeds 94°F (34.4°C) (except at the time of initial compression) during the first six hour PRC Table, do not subject the patient to a repeat PRC Table.

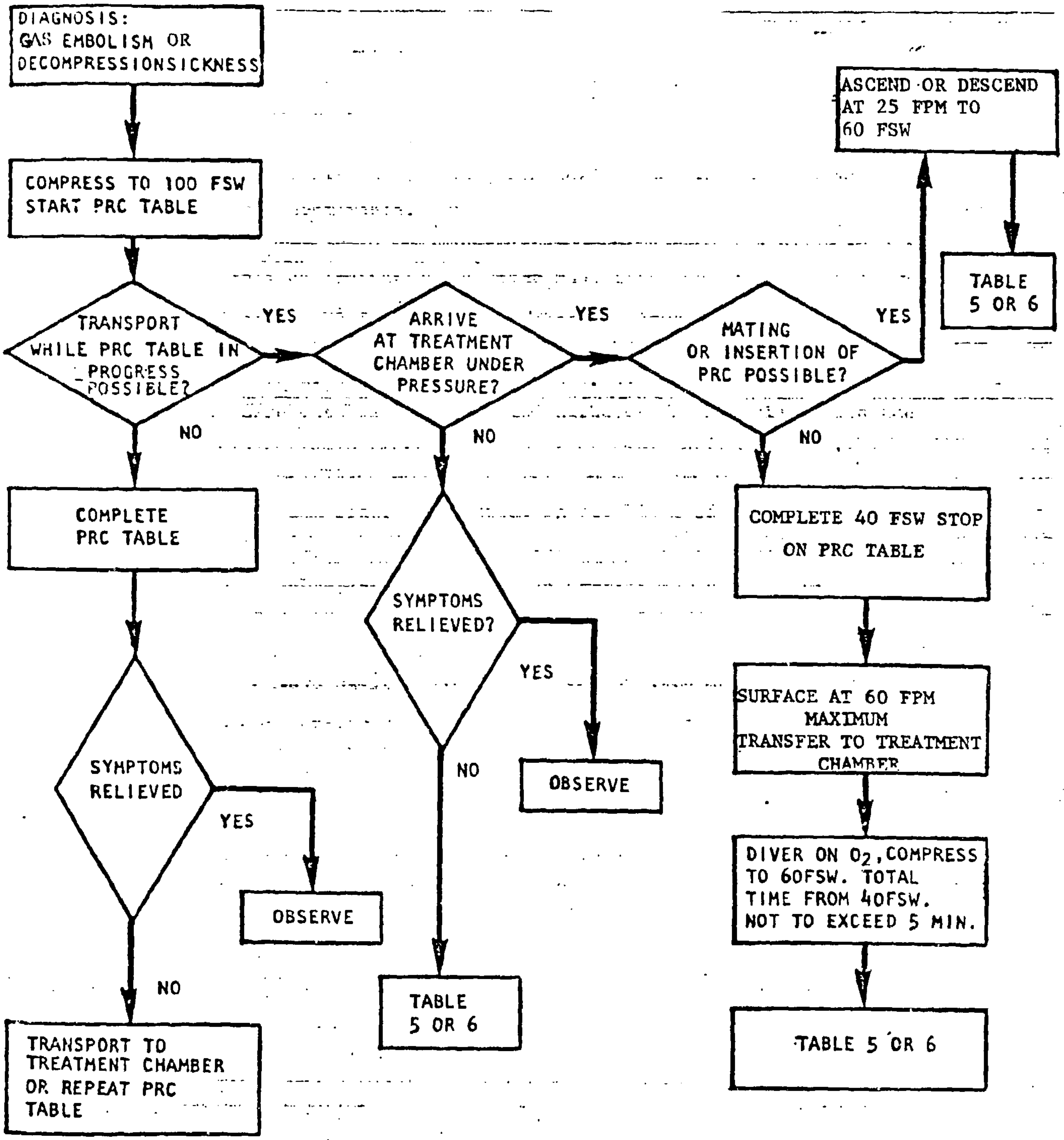



FIGURE 2-2: TREATMENT OF DECOMPRESSION SICKNESS AND GAS EMBOLISM

TABLE 2-1

PRC RECOMPRESSION TREATMENT OF DECOMPRESSION SICKNESS AND GAS EMBOLISM USING AIR

NOTES:

1. Use - treatment of decompression sickness and gas embolism.
2. Descent rate - 25 ft/min.
3. Ascent rate - 1 min between stops.
4. Time at 100 ft - includes time from surface.
5. VENTILATION SCHEDULE

| DEPTH | VENT TIME | ELAPSED TIME |
|---|---|---|
| 60' | 1 min | :44 |
| 50' | 1 min | 1:15 |
| 40' | 1 min | 1:46 |
| 30' | 1 min | 2:17 |
| 30' | 1 min | 2:47 |
| 20 | 1 min | 3:18 |
| 20' | 1 min | 3:48 |
| 10' | 1 min | 4:19 |
| 10' | 1 min | 4:49 |
| 10' | 1 min | 5:19 |
| 10' | 1 min | 5:49 |

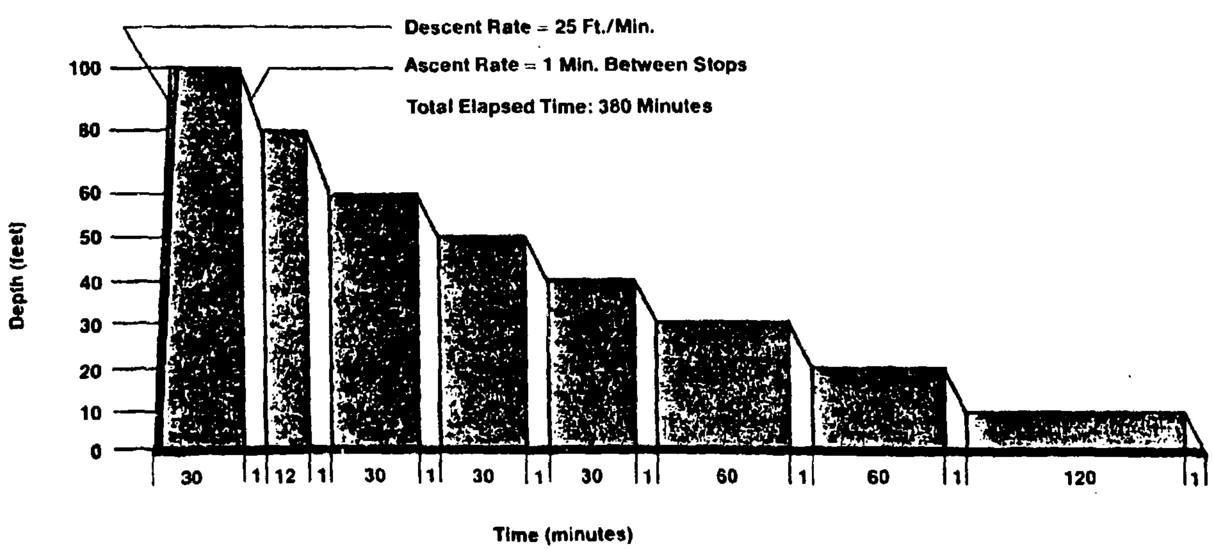
TABLE 1A

| Depth (ft) | Time (min) | Breathing Media | Total Elapsed Tim (min) |
|---|---|---|---|
| 100 | 30 | Air | 30 |
| 80 | 12 | Air | 43 |
| 60 | 30 | Air | 74 |
| 50 | 30 | Air | 105 |
| 40 | 30 | Air | 136 |
| 30 | 60 | Air | 197 |
| 20 | 60 | Air | 258 |
| 10 | 120 | Air | 379 |
| 0 | 1 | Air | 380 |

NOTE:
ADDITIONAL VENTS MAY BE GIVEN AT ANYTIME WITH THE PERMISSION OF THE DIVE SUPERVISOR.

AIR REQUIREMENTS THREE SETS OF 90's CHARGED TO 3000 pisg.

DEPTH/TIME PROFILE




Enclosure (4)

## MK 16 UBA TECHEVAL ACCIDENT/INCIDENT PROCEDURES

1. Introduction

This is the first open sea use of the MK 16 UBA. The diving procedures and decompression tables for this UBA are generally the same as for the MK 15 which is in Fleet use. The accident/incident procedures are designed to guide supervisory and medical personnel to handle failures of the life support functions of the UBA or problems that the diver may encounter because of a long arduous dive. Problems which may require emergency procedures are categorizied as follows:

(a) MK 16 Failure.

(1) Flooding

(2) Oxygen control

(3) Carbon dioxide absorbent

(4) Oxygen depletion

(5) Diluent depletion

(b) Decompression Sickness

(c) Oxygen toxicity

(d) Nitrogen narcosis

(e) Cold

(f) Exhaustion

2. General Emergency Procedures

a. Oxygen toxicity could result if the MK 16 fails or the diver improperly adds $0_2$ at depth. If a diver experiences oxygen toxicity symptoms, he should ascend from the bottom, check his secondary, purge with diluent if required, and secure his oxygen bottle if necessary. Use normal signals,

left bottom, arrived lazy shot, etc., if possible. He should switch to SCUBA as soon as possible, and begin decompression according to procedures using Equivalent Air Depth. If a diver experiences a convulsion, his dive buddy should try to maintain his depth until the convulsion has subsided and hit the diluent purge button on the rig. When the convulsion has subsided, the buddy diver will make a controlled ascent to the surface assisting the disabled diver.

b. Decompression sickness is improbable on the 40 FSW dives but is possible on all the deeper dives. The diver could develop decompression sickness during decompression. If symptoms are recognized, the diver should signal for assistance from the standby diver (2-2-2 pulls). The stricken diver should attempt to complete decompression stops through the 30 FSW stop if possible. He can then directly surface, using signals from the 30 FSW stop. If the diver is uncertain as to the cause of symptoms, he should switch to the air SCUBA.

c. The emergency procedure for any diver who arrives on the surface with symptoms or signs of decompression sickness or air embolism is to immediately compress the diver in the Portable Recompression Chamber (PRC), begin the PRC Table and plan for an orderly transfer to the double lock recompression chamber on shore.

d. If two divers have symptoms and require recompression, the Dive Medical Officer or Hospital Corpsman Diving Technician is to recompress one in the PRC and begin oxygen by mask and intravenous Ringer's lactate on the other while proceeding to the double lock recompression chamber.

e. Nitrogen narcosis may occur at 120 and 150 FSW. If narcosis persists and seems to get worse on the bottom, the diver or divers will ascend and give normal signals for decompression. Once the diver leaves the bottom, symptoms shculd stop.

f. If the diver becomes cold or exhausted before finishing the dive, he should begin the procedures for decompression and surfacing.

3. Procedures for Specific Depth Dives

The diver's actions for failure of the MK 16 depend upon the function lost. If the UBA can be manually operated, the diver is to initiate the procedures for decompression and surfacing. Switching to air SCUBA procedures are available for the 60, 90, 120, and 150 FSW dives.

a. 40 FSW dives

The divers are buddy-line-attached swimmers towing a marker buoy. Decompression sickness is not a consideration. If a diver has MK 16 failure or a problem, divers are to come to the surface controlling the rate of ascent at less than 60 ft/min if possible.

b. 60 and 90 FSW dives

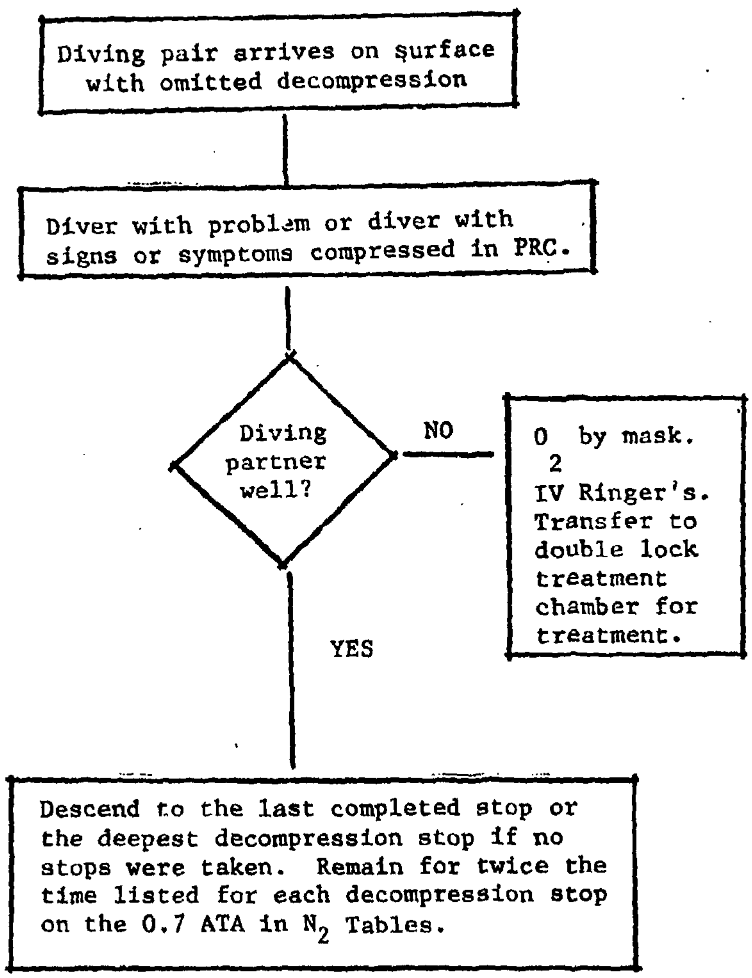
(1) The divers are buddy-line-attached swimmers towing a marker buoy. Decompression sickness is possible if a controlled ascent with appropriate decompression stops is not followed.

(2) If there develops a MK 16 failure or a diver problem, the divers will signal 1 pull on the float marker line, and when returned from topside, four pulls to indicate leaving bottom. A Dive Supervisor, seeing the float

signal, will lower the lazy shot with SCUBA cylinder filled with air. The diver who has a problem or a rig failure, on reaching the lazy shot, will go on air SCUBA if necessary. Decompression can be continued on the MK 16 if it is operable. The divers will give one pull when the diver is ready to commence decompression on the lazy shot. The buddy diver should remain on his MK 16 and assist the other diver. The Dive Supervisor will control decompression and complete all stops on the 0.7 ATA $P_{O_2}$ in $N_2$ Table if the divers are on MK 16. If one diver is on air SCUBA, both divers will complete the 0.7 ATA $P_{O_2}$ in $N_2$ Table to the first stop on the Air Equivalent Table, then complete all the appropriate Standard Air Table stops.

(3) The appropriate Air Equivalent Table will be calculated using the 100 FSW Standard Air Table for the 90 FSW actual depth dives, and the 60 FSW Standard Air Table for the 60 FSW actual depth dives. The bottom time used to select the table will be all the time from leaving the surface to the first stop on the appropriate Standard Air Table, and includes the times of the stops on the 0.7 ATA $P_{O_2}$ in $N_2$ Table.

(4) If a diver surfaces because of MK 16 failure or any other problem and has omitted any decompression, that diver will have immediate recompression treatment in the PRC. His diving partner will also have omitted decompression but can descend again to the depth of his last completed stop or to the deepest decompression stop if no stops were taken. He will remain for twice the time listed for each decompression stop on the 0.7 ATA $P_{O_2}$ in $N_2$ Table. Keep the surface interval less than 5 min if possible, but the Dive Supervisor must check the diver's rig to ensure it will sustain the diver for the extended decompression obligation. The Dive Supervisor must be prepared to switch this diver from his MK 16 to a standby MK 15 if necessary so that the added decompression time will not be compromised by depletion of gas supplies or carbon dioxide absorbent failure.


Diving pair arrives on surface with omitted decompression
Diver with problem or diver with signs or symptoms compressed in PRC.
Diving partner well?
NO
$O_2$ by mask. IV Ringer's. Transfer to double lock treatment chamber for treatment.
YES
Descend to the last completed stop or the deepest decompression stop if no stops were taken. Remain for twice the time listed for each decompression stop on the 0.7 ATA in $N_2$ Tables.

Enclosure (5)

c. 120 and 150 FSW

(1) The divers are tethered by separate life lines. Decompression sickness is possible even following the appropriate decompression tables. If one diver has a problem or a rig failure, he should ascend to the SCUBA cylinder filled with air secured 10 FSW from the bottom. The other diver will assist him and when ready to come up to their lazy shot will give a signal of 1 pull followed by four pulls. A further SCUBA cylinder will also be secured to the lazy shot. On arrival at the lazy shot, a signal of one pull will be given by the divers. When on their stops, the diver on the SCUBA will give the signal of two pulls - two pulls - two pulls (require standby divers). The standby diver will go down and check the divers and report back to the Dive Supervisor.

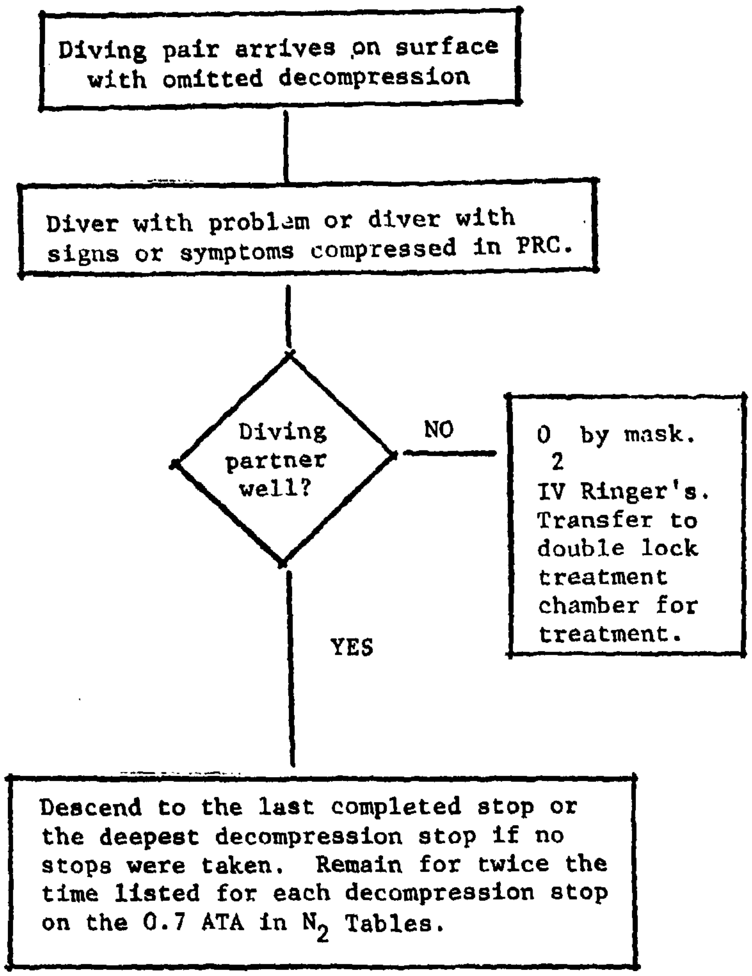
(2) The partner who has no problem should remain on his MK 16, remain on his line, and continue an orderly decompression on the 0.7 ATA $P_{O_2}$ in Nitrogen Table if the diver with the problem is on air SCUBA appears well.

(3) The diver on air SCUBA is to complete all stops on the 0.7 ATA $P_{O_2}$ in Nitrogen Table to the first stop on the Air Equivalent Table, then complete all the appropriate standard air stops. The Air Equivalent Table is calculated using the 130 FSW Standard Air Table for the 120 FSW actual depth dive and the 170 FSW Standard Air Table for the 150 FSW actual depth dive. The bottom time used to select the table will be all the time from leaving the surface to the first stop on the appropriate Standard Air Table.

(4) If a diver surfaces because of MK 16 failure or any other problem and has omitted any decompression, that diver should have immediate

recompression treatment in the PRC. If his diving partner also surfaces he will have omitted decompression but can descend again to the depth of his last completed stop or to the deepest decompression stop if no stops were taken. He should remain at each decompression stop twice the time listed on the 0.7 ATA in $N_2$ Table. The surface interval will be kept to less than 5 minutes if possible. The Dive Supervisor must check the diver's rig to ensure that it will sustain the diver for the extended decompression obligation. The Dive Supervisor should be prepared to switch this diver from his MK 16 to a standby MK 15 if necessary so that added decompression time will not be compromised by depletion of gas supplies or carbon dioxide absorbent failure.

## 120 AND 150 FSW DIVES




Enclosure (5)

MK 16 MOD 0 UBA - NUMBER OF DIVES, DEPTHS AND DURATION

(Taken from the Master Dive Log)

| Location | Depth (FSW) | Number of Dives | Duration of each dive |
|---|---|---|---|
| Test Pool | 15 | 30 | 0:05 to 1:00 |
| Open Sea | 12 | 4 | 0:30 |
| | | 4 | 3:00 |
| | 20 | 2 | 1:30 |
| | | 24 | 2:00 |
| | 30 | 8 | 2:00 |
| | | 6 | 3:00 |
| | 40 | 1 | 0:30 |
| | | 10 | 0:45 |
| | | 7 | 1:00 |
| | | 38 | 2:00 |
| | | 20 | 3:00 |
| | | 8 | 4:00 |
| | 60 | 7 | 1:12 |
| | 90 | 8 | 1:08 |
| | 120 | 8 | 0:41 |
| | 150 | 8 | 0:55 |

Total Number of Dives - 193

Enclosure (2)

MK 16 MOD 0 UBA - MTBF DURING TECHEVAL

1. Life Support Components

a. 1 failure occurred.

b. Failure - UBA flood-out.

(1) Time - Approximately 40 hours.

(2) Cause - Use of tie-ties as hose clamps.

(3) Remedy - Temporary use of AGA banding clamps. Permanent fix to be non-magnetic hose clamps which can be easily removed for maintenance.

2. Mission Support

a. 15 failures occurred.

b. Failure - 6-Primary batteries died.

(1) Time - Approximately 35.5 hours
50 hours
131 hours
202.5 hours
242.5 hours

(2) Cause - Lack of information on charging and discharging curves of the battery caused the pre-dive battery test to indicate a fully charged battery when this was not the case.

(3) Remedy - Investigate primary battery reliability, and amend charging routine and pre-dive check.

c. Failure 1 - Primary battery at primary electronics lead.

(1) Time - Approximately 13.5 hours.

(2) Cause - Connecting wires chaffed.

(3) Remedy - Re-locate Winchester connector into electronics bulkhead, and add extra protection to wires on the battery (i.e. heat shrink).

d. Failure - 1-"O" ring on $O_2$ regulator seat for $O_2$ bottle split.

(1) Time - Approximately 35 hours.

(2) Cause - "O" ring seal not correctly fitted into seat.

(3) Remedy - Remove completely; fitted by mistake.

e. Failure - 1-hose leak.

(1) Time - Approximately 178 hours.

(2) Cause - Possible human error in handling and the excessive weight of the Full Face Mask block assembly causing the hose to fail.

(3) Remedy - Fit webbing carrying handle, and review need for FFM weighted block.

f. Failure - 2-Primary Display malfunction and then Primary Electronics malfunction. Failures possibly related.

(1) Time - Approxmately 277.5 hours
285 hours

(2) Cause - Hybrid Chip failure in Primary Electronics.

(3) Remedy - Review reliability of hybrid chips.

g. Failure - 1-Primary Electronics flood-out via vent screw.

(1) Time - 277.5 hours.

(2) Cause - Possible human error in not checking the vent screw tightness during pre-dive check.

(3) Remedy - Review pre-dive check to ensure the vent screw tightness step is clearly defined.

h. Failure - 1-Secondary Electronics wires crushed.

(1) Time - Approximately 285 hours.

(2) Cause - Wires incorrectly potted. The wires are too close to the outside radius of the secondary case and were crushed by the secondary cap.

(3) Remedy - Re-pot wires further in towards the center of the secondary case.

i. Failure - 1-Loose fuze in primary electronics.

(1) Time - Approximately 145.5 hours.

(2) Cause - Fuze cover loose.

(3) Remedy - Re-locate fuze in the primary electronics alongside the thumb-wheels. The fuze cover can then be checked every time the set is recalibrated.

j. Failure - 1-Primary electronics flood-out.

(1) Time - Approximately 202.5 hours.

(2) Cause - Crimped "O" Ring on primary electronics case.

(3) Remedy - Review method of checking "O" Rings, and investigate checking primary electronics seal by pulling vacuum through vent screw penetrator.

MK 16 MOD 0 UBA SPARE PARTS OUTFIT - PROPOSED LIST

Spare Parts For Three MK 16 MOD 0 UBA's

1 Primary cable

1 Electronics cable to canister

1 Canister securing nut (starbolt)

1 Secondary display assembly

1 Primary display assembly

6 Hoses - mouthpiece

6 Fuses 3/10 amp

6 Large yellow thread protectors (outside)

6 Sets of harness pins

1 Vent valve complete

3 $O_2$ by-pass Dill valves

1 Primary electronics vent valve screw

3 $O_2$ in-line filters

12 Upper moisture pads

3 Pad compression

2 Check valve housings (AGA)

2 Sets AGA O-rings complete (AGA)

6 Sets hose clamps complete

1 Set of all screws/washers/nuts/etc.

1 Diaphragm clamp

3 Diluent add Dill valves

1 Diluent regulator complete

1 Diluent regulator spring

1 Set diluent regulator shims

1 Set by-pass springs and washers

7 Primary battery chargers

3 Grommett, sensor

1 Secondary cable

1 Diluent HP hose

1 Upper moisture pad securing ring

1 Primary electronics assembly (including Lee valve)

2 Pressure gage - adapter couplings

6 Dunce caps

9 Primary batteries

21 Secondary batteries

1 Diaphragm

3 $O_2$ pneumatics check valves

3 Diluent by-pass Dill valves

1 Backpack cover latch complete

3 Diluent in-line filters

12 Lower moisture pads

1 Spare mouthpiece complete (AGA)

6 Check valves (AGA)

2 Screws for mouthpiece collar (AGA)

1 Set of all O-rings used or cleaned in pre-dive/post-dive and PMS

1 Set hydrophobic filters

1 $O_2$ regulator complete

1 $O_2$ regulator spring

1 Set $O_2$ regulator shims

1 By-pass valve button

1 $O_2$ HP hose

Enclosure (4)

MK 16 MOD 0 UBA - SPECIAL TOOL REQUIREMENTS

1. Primary Electronics Lid removal tool.
2. Dill Valve removal tool.
3. Plastic screw-driver for Secondary Display Cal Pot adjustment.
4. Teflon-faced pliers.
5. Diluent pressure gage non-magnetic.
6. $O_2$ pressure gage non-magnetic.
7. Tool for cleaning SODASORB particles from inside faces of scrubber assembly.
8. Scales for weighing cannister (0-20 lbs).
9. Digital multimeter.
10. Vent valve spanner set.

Enclosure (5)

MK 16 MOD 0 UBA - TRAINING COURSE PLAN AND LEARNING OBJECTIVES - NEDU COMMENTS

1. The present Navy Training Plan (NTP) states that a basic MK 16 MOD 0 UBA Course will be 8 days and a refresher 5 days. These course lengths appear to be very short as the MK 16 MOD 0 UBA, while not a complex equipment, requires a greater understanding of its operation and maintenance than previous EOD diving equipments. It is recommended that the course be designed without time constraints and the course length, vis-a-vis course content, be reviewed to meet training constraints such as number of days available.

2. The Instructional Systems Development - Phase II Preliminary appears to be based on the Pre-dive and Supervisor Check Lists. This is not considered to be a practical method; and, when used during TECHEVAL, confused the Dive Subjects. A more practical approach would be to use the basic format in the O&M Manual plus other minor adjustments, i.e.:

a. Medical Aspects appertaining to the MK 16 MOD 0 UBA.

b. Equipment function and fit by sub-assemblies (including tools and test equipment).

c. Total equipment operation.

d. Mixed Gas Transfer System.

e. Pre-dive checks.

f. Emergency procedures.

g. Post-dive checks.

h. Trouble shooting.

i. Maintenance.

j. Supervisor checks.

k. Use of decompression tables.

3. To assist in the practical instruction of emergency procedures, a method of manipulating the primary display and switching the primary battery on and off should be developed. An instructor display should be available showing whether the "LEE" valve is open or shut at the time the battery power is turned off, and a repeat secondary display should be situated topside to enable the instructor to monitor UBA status. A bone-conductor type diver/topside communicator will be required to use this proposed training aid effectively.

Enclosure (6)

MK 16 MOD 0 UBA - ENGINEERING CHANGE PROPOSALS (ECP's)

1. As a result of not only TECHEVAL but all DT III, the following ECP's are proposed. Each sub-assembly is taken in turn as laid out in the Parts Lists in the DRAFT O&M Manual using part descriptions from these lists.

2. Scrubber Assembly

a. The Assembly Diaphragm, on several occasions, was incorrectly fitted to the Center Section Assembly and prevented the correct operation of the Diluent add valve. The Band Assembly holding the Assembly Diaphragm also was incorrectly fitted. The O&M Manual should stress the need to ensure the Assembly Diaphragm is correctly fitted to the Center Section Assembly and the Band Assembly located such that the tensioning screw is easily accessable when the Scrubber Assembly is fitted into the back-pack and that the screw does not foul the correct fitting of the Diluent Bottle. The addition of a lip to the Assembly Diaphragm will ensure the diaphragm is evenly fitted to the Center Section Assembly prior to the Band Assembly being tightened.

b. The Absorbent Pads (also called Discs) are manufactured of a material that reacts with the caustic solution that can exit the Canister Assembly. This material should be changed to a non-reactive material. The Top Pads (three) should be replaced with one thick pad the same thickness as the Bottom Pad.

c. The Bottom Pad Support was removed before TECHEVAL as not required. It had not been part of the MK 16 MOD 0 UBA outfit in previous tests.

d. The Assembly Cover is secured to the Center Section by a Star Bolt. During initial tests, it was noted that the cover can flex. It is recommended that the cover is secured with four pins and locking slides around the lower edge of the cover. This will not only hold the cover firmly on, but prevent the "O" ring seal from being broken and relieve tension off the Center Section Assembly. One cover was cracked during TECHEVAL when a UBA was dropped onto the bottom of the dive boat striking a sharp edge. The divers also reported that fish were attracted to the reflection off the cover. The recommended change for these two problems is to leave the Assembly Cover as it is now, but use the Backpack Cover configuration as provided for the MK 15 UBA.

e. The Band Assembly nylon screw showed excessive wear for the number of times this screw was used. This may have been due to incorrect screw-drivers being used, and should be further examined during OPEVAL. The rivets holding the band and the nylon adjustment fixture together showed rust. This should also be examined further during OPEVAL.

3. Center Section Assembly

a. The exhalation and inahaltion ports should be increased to 1-1/4" diameter. The hose connections should also be larger, and the hose fittings made such that the internal diameters of the hoses and the ports remains equal.

b. Consideration should be made to changing the support lid as noted in 2.d. above. This can then enable the Bracket, Sensor, to be part of the moulded center

section structure with the Sensor, Hyperbaric Oxygen then becoming a plug-in unit thereby eliminating many small metal parts, including the Star Bolt.

c. The connection wires for the sensors are exposed, and require care to avoid catching them with the Canister Assembly during pre-dive assembly. These wires would also be eliminated with the inclusion of paragraph b. above as an ECP.

d. The sensor bracket should be clearly numbered (1 to 3) to ensure the sensor and the thumb-wheel calibration switches in the electronics assembly are easily identified, i.e. 1=1, 2=2, 3=3.

4. <u>Canister Assembly</u>

a. The Pad Compression was "eaten" away by the caustic reaction of the SODASORB and should be replaced with a new non-reactive material.

b. The ribs on the bottom outside of the Housing Canister can foul on the "stand-off" screws by the Exhalation Port. The Housing Canister should be etched with line up marks or a gap left in all the lower ribs.

5. <u>Electronics Assembly</u>

a. The Cover, Battery Electronics is difficult to remove, and the present special tool is causing wear on the Cover and Assembly, Electronics Housing. A modification should be made to the Cover to allow easier removal.

b. The Ring, Locking became very tight on at least two of the PPM's, and required excessive effort to remove it. In some cases use of a chain wrench was required. The reason should be investigated and overcome.

c. The battery connectors should be re-sighted with the female connector being moulded into the battery lower bulkhead. This connector must be watertight. The present cable penetrators are not.

d. The Electronics Fuze should be re-sighted from the bottom of the electronics section to a position next to the thumb-wheel pots. This will enable easy replacement of the Fuze by the operator.

e. The Assembly, Oxygen Valve should be made part of the whole electronics assembly, and the present requirement to replace the valve if it fails should become a replacement of the whole electronics assembly. This will enable a better and permanent water tight seal to be fitted between the Valve and Electronics Assembly.

f. There is no way to check the Electronics Assembly for water-tightness. It is considered that a leak test using a low vacuum by fitting a vacuum pump and gauge into the vent screw hole during pre-dive procedures, could provide the answer. Further investigation is recommended.

g. Many of the divers indicate that an External "ON-OFF" switch should be fitted to enable long transits to the dive sight with the set checked-out ready for diving but with no discharge on the battery. The problem of the battery discharging may be overcome once the reliability of both the electronics and batteries have been established. However, the incorporation of an "ON-OFF" switch should still be considered.

6. Primary Display Assembly

a. The clarity of the LED's was a major concern during TECHEVAL. In bright sunlight and clear water, the LED could not be clearly seen. The green LED also turned yellow at approximately 15 FSW. It is recommended that back-shielding be provided to ensure the LED's are not blocked out by background lighting. There were no night dives so the clarity at night was not tested. A night evolution should be carried out during OPEVAL and the clarity of the LED's re-evaluated.

b. There were several comments from the divers on the size and location of the Primary Display. This should be checked again during OPEVAL.

c. The light code caused comment. It was considered to be confusing as the indication still requires the secondary to be checked and a decision to be made as to what a change of lights really means. The requirements of the Primary Display indications vis-a-vis the EOD mission and operational requirement should be reviewed and re-established with any changes incorporated into the production equipments such as using one (RED) warning light which indicates any of the rig failures/malfunctions and the diver then using the Secondary and aborting the dive.

7. Secondary Display

a. The Secondary Display is large and bulky; and, when attached to the harness, is difficult to locate and re-connect when the MK 16 MOD 0 UBA is worn with the MK 4 Life Preserver. The Snap (Spring) hook is not reliable. It can jam open or "jump" its hook. It is not possible to check if the unit is water-tight prior to the dive. The readout is difficult to locate on the cylindrical housing, and the read out is poor in low visibility. The Secondary Battery can stick in the battery pocket due to suction, and the battery connectors should be reversed (the female in the bulkhead not the male) to prevent irrepairable damage to the male connector. The internal bulkhead should be water-tight. For all of the above problems it is recommended that a new design secondary be produced of a much smaller size with a rechargeable battery common to the Primary Battery (i.e. 6V gel battery) and located in the Backpack. A further recommendation of combining this display with a shared-time HP bottle gage display would also enhance the overall diver safety and operation. (The gage will be referred to in a later sub-paragraph.)

8. Regulator Assemblies, Oxygen - Diluent

a. The Bottle Valve Assembly is difficult to pass through the Yoke, Regulator because the Regulator Assembly is fixed to the Backpack. Towards the end of TECHEVAL brass slivers were being pressed into the bottle "O"ring and causing high usage of the "O"rings. The hardness of the metal and design of the Yoke should be reviewed. (This will be referred to in a later sub-paragraph.)

b. The Knob, Regulator is difficult to tighten and release, and should be replaced with a "T" handle.

9. Bottle and Valve Assemblies, Oxygen - Diluent

a. The handle on the Valve Assembly is difficult to turn while in the water. The backpack access to the handle is very poor when wearing gloves, and needs to

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be enlarged. The need to be able to turn off the bottles in the water is essential as this evolution is a listed Emergency Procedure. The design should be reviewed in conjunction with sub-paragraph 8a above.

b. The Bottle Assembly interface with the Regulator Assembly started to show wear towards the end of TECHEVAL, and slivers of brass were being pressed into the bottle "O"ring. The hardness of the metal should be reviewed. (See sub-paragraph 8a above.)

c. The present bottle color coding should be increased to ensure the bottles cannot be interchanged accidentally, i.e. Oxygen all green, diluent all black or, at least, color-coded around the bottle necks.

10. Cover Housing Assembly

a. The whole of the MK 16 MOD 0 UBA components are a tight fit in the Backpack and the Cover Housing. On two of the PPM's, it was difficult to fit the Cover Housing. It is recommended that the Backpack size be slightly increased, and a new design Cover Housing, as presently used with the MK 15 UBA, be introduced. (See sub-paragraph 2.d. above.)

b. The Primary Cable Securing Clamp on the Backpack broke on several occasions, and the Cover Housing fouled the cable. The design should be reviewed and modified as necessary to overcome this problem.

11. High Pressure Gage Assembly

a. The present Gages are too small, fog up and are located in the wrong place. They should be changed and care taken to ensure they can be easily read under all operational diving conditions.

b. The location and securing method of the Gages to the Harness needs to be improved. Account should be taken of the fit of the MK 4 Life Preserver and the location of the Gages.

c. It is recommended that as a long-term goal, the Oxygen and Diluent Gages be re-designed as one unit possibly combined with a new Secondary Display. Using pressure transducers, it should be possible to reduce the gages to a time-sharing LCD using the same power source as the Secondary Display. This will reduce the number of cables and fittings from the Backpack to the front of the Harness from 3 to 1. It should be noted that when the Secondary Display has to be checked during most Emergency Procedures, it is also necessary to check the H.P. Gages. A combined design will therefore be easier for the operator.

12. Harness Assembly

a. The Harness Assembly requires a lifting point to be fitted between the Shoulder Straps and behind the diver's neck to assist with the handling of the UBA when out of the water.

b. The pins securing the harness to the backpack come loose and fall out. The pins should be changed.

Enclosure (7)

c. The Quick-Release Buckle on the Waist Strap is similar to that of the MK 4 Life Preserver. Should there ever arise a need to ditch the set while in the water it could confuse the diver as to which buckle he should release. This problem should be further reviewed during OPEVAL.

d. During TECHEVAL and other pool tests at NEDU, the divers have voiced an opinion that an optional jockstrap should be fitted. The desirability of a jockstrap should be examined during OPEVAL.

e. Some of the divers had difficulty with their weight belt and the basic configuration of the set. This was with those divers who required a large number of weights. No solution is offered but the use of large hip weights was not totally successful due to the side hinges on the backpack getting in the way. This problem whould be further evaluated during OPEVAL.

13. Pneumatics Assembly

a. The Pneumatics Assembly has one unsolved problem. When carrying out bench tests it was noted that when the Diluent Bottle was removed and the Oxygen Bottle still connected up, when the Oxygen By-pass was operated to remove HP oxygen from the Oxygen Regulator prior to Oxygen Bottle removal, oxygen leaked up through the Diluent Regulator. The reverse happened when the Oxygen Bottle was disconnected with the Diluent Bottle connected up and the Diluent By-pass activated. The only logical conclusion is that the By-pass Dill Valve Housings allow gas to leak back up past the outside of the Dill Valve. The concern is that the oxygen clean system can be contaminated with air and that oxygen can pass through an unclean system in the diluent side of the assembly. This problem needs to be resolved and gas contamination prevented.

b. The by-pass push buttoms should be changed to indicate $O_2$ or diluent. It is recommended that the same code is used as the MK 15 UBA, $O_2$ has an "O" and diluent has a "Cone".

14. Shipping Container

a. The Shipping Container cannot hold the Full Face Mask (FFM). If the FFM is removed from the system, the container is large enough, but its weight, plus the MK 16 MOD 0 UBA, is over 70 lbs. Therefore, is can not be shipped as personal baggage by air freight. It may be desirable to have a second container for the HP Bottles (which could include the FFM if still required) thereby keeping the weights of each container below 70 lbs. The HP bottle container is also desirable to enable the bottles to be safely removed from the UBA and stowed where they cannot roll around.

15. Full Face Mask (FFM)

a. Considerable effort has been expended to overcome the problems arising from the hydro-static lung loading pressure variations of the MK 16 MOD 0 UBA and the non-magnetic FFM interface. The nose-clearing device in the FFM was also found to be unsuitable due to the need to over-tighten the FFM to overcome the face mask leaks. After considerable effort to resolve the FFM squeeze effect, gas leaks, water leaks, nose-clearing device and general comfort, it is recommended that the FFM be replaced with a mouthpiece and swim-mask. The swim-mask should be a low

volume "pinocchio"-type which will reduce the face-squeeze problem. The mouthpiece should have a retaining strap to prevent the hydro-static lung loading pressure variation causing the mouthpiece to "blow-out" of the diver's mouth.

b. The present hose clamps require replacement with a non-magnetic easily removeable type that will ensure a water-tight seal under all operational diving conditions.

16. Buoyancy

a. Several divers complained of poor buoyancy control in shallow water (0-30 FSW). This is a real problem when attempting to maintain accurate depths for decompression. It is recommended that either a descending line be used for all decompression dives or a bouyancy compensator is introduced as part of the MK 16 MOD 0 UBA outfit.

17. Compatibility with other essential diver's equipments

a. The MK 16 MOD 0 UBA should be tested with all the diver-worn equipments proposed in the EOD operational scenario. This should include all diving suits (dry and wet types) and life preservers. TECHEVAL did not fully exploit this aspect of the total EOD system.

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MK 16 MOD 0 UBA - PRE-PRODUCTION MODEL (PPM) CONFIGURATION DIFFERENCES

1. All PPM's

a. Sensor ID should be permanently marked.

b. Dunce caps to be available for $O_2$ and diluent regulators when bottles not fitted.

c. Dust caps to be available for inhalation/exhalation ports when hoses disconnected.

2. PPM 1

a. Thumb wheel calibration pots in a different order to the other 5 PPM's - re-arrange order.

b. Bottle cushion pads missing - fit new pads.

c. HP gage adaptors of old design - change to new design.

d. Secondary male winchester connector broken - refit with new connector.

3. PPM 2

a. Bottle cushion pads missing - fit new pads.

b. HP gage adaptors of old design - change to new design.

c. Diluent regulator assembly, knob, regulator - change to tee-bar type.

d. Diluent and $O_2$ regulator support bracket screws incorrect type - change to correct type.

e. Primary electronics mount bracket screws are a different type to other PPM's - change screws and/or fitting.

4. PPM 3

a. Bottle cushion pads missing - fit new pads.

b. Diluent and $O_2$ regulator assemblies, knob, regulator - change to tee-bar type.

c. Rubber pads on regulator support brackets - to be fitted.

d. Screw missing from latch assembly - replace.

5. PPM 4

a. Latch broken - replace.

b. Primary electronics defective - repair.

c. Diluent and $O_2$ regulator assemblies, knob, regulator - change to tee-bar type.

6. PPM 5

a. Diluent and $O_2$ regulator assemblies, knob, regulator - change to tee-bar type.

7. PPM 6

a. Diluent and $O_2$ regulator assemblies, knob, regulator - change to tee-bar type.

b. Secondary assembly wiring crushed - replace and re-pot towards center of assembly and clear of cap.

Enclosure (8)

## MK 16 MOD 0 UBA - ADDITIONAL SPARE PARTS TO OVERHAUL UBA'S AND/OR BE AVAILABLE FOR OPEVAL

| PARTS | NUMBER |
|---|---|
| Spare mouthpiece hoses | 30 |
| Upper moisture pads | 30 |
| Lower moisture pads | 30 |
| Pad Compression | 6 |
| Sets hydro-phobic filters | 6 |
| O-rings for bottle stems | 24 |
| O-rings for hose to backpack coupling | 24 |

Enclosure (9)

MK 16 MOD 0 UBA - SUMMARY OF PRIMARY AND SECONDARY BATTERY USAGE RATES

1. Approximate usage rate for the primary battery during TECHEVAL are:

a. 31 batteries used.

b. 20 batteries became unserviceable.

c. Average time for 20 batteries which became unserviceable - 27 hours, 26 minutes (maximum - 84 hours, 42 minutes; minimum - 0 hours).

d. Average time for 11 batteries still in use - 33 hours, 20 minutes (maximum - 71 hours, 20 minutes; minimum - 4 hours, 38 minutes).

2. Approximate usage rate for the secondary battery during TECHEVAL are:

a. 32 batteries used.

b. 25 batteries became unserviceable.

c. Average time for 25 batteries which became unserviceable - 26 hours, 17 minutes (maximum - 65 hours, 31 minutes; minimum - 0 hours).

d. Average time for 7 batteries still in use - 40 hours (maximum 68 hours, 24 minutes; 6 hours, 5 minutes).

3. The usage for the primary batteries increased towards the end of TECHEVAL due to a hand-built battery charging/testing station being introduced vice the previous method of charging and testing.

4. The usage rate of the secondary batteries varied with the different job lots of the "N" cells used.

MK 16 MOD 0 UBA PRIMARY BATTERY CHARGING STATION AND METER FOR SECONDARY BATTERY

CHECK WIRING DIAGRAM AND OPERATING PROCEDURE

NOTE: Color code refers to colored sectors on meter faces.

| Primary Voltmeter | Primary Ampmeter | Secondary Battery Tester |
|---|---|---|
| Red = 0 - 4.66 VDC | Red = 6.80 - 119.0 mA | Red = 0 - 7.40 VDC |
| Orange = 4.66 - 5.40 VDC | Yellow = 52.2 - 68.0 mA | Orange = 7.40 - 8.94 VDC |
| Yellow = 5.40 - 5.95 VDC | Green = 17.5 - 52.2 mA | Green = 8.94 - 10 VDC |
| Green = 5.95 - 8.00 VDC | | |

1. Good charger (no load)

   a. Voltmeter - Orange (switch UP)

   b. Ammeter - Green (switch UP)

2. Bad charger (no load)

   a. Voltmeter - Red (switch UP)

   b. Ammeter - Green (switch UP)

3. Bad charger (with load)

   a. Voltmeter - Green or Yellow (switch UP)

   b. Ammeter - No Flunctuation

4. Bad battery

   a. OPEN

      (1) Voltmeter - Green or Yellow

      (2) Ammeter - No Flunctuation

   b. SHORT

      (1) Voltmeter - Green (high)

      (2) Ammeter - Red (high)

   c. REVERSED LEADS

      (1) Voltmeter - Red (pegged)

      (2) Ammeter - Red (high)

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d. DEAD BATTERY

(1) Voltmeter - Red

(2) Ammeter - Red

5. Charging battery

a. Voltmeter - Yellow or Green

b. Ammeter - Yellow or Green

6. Fully charged battery

a. Voltmeter - High in Green

b. Ammeter - High in Green

7. If both meters fall to RED in a load condition, discard battery.

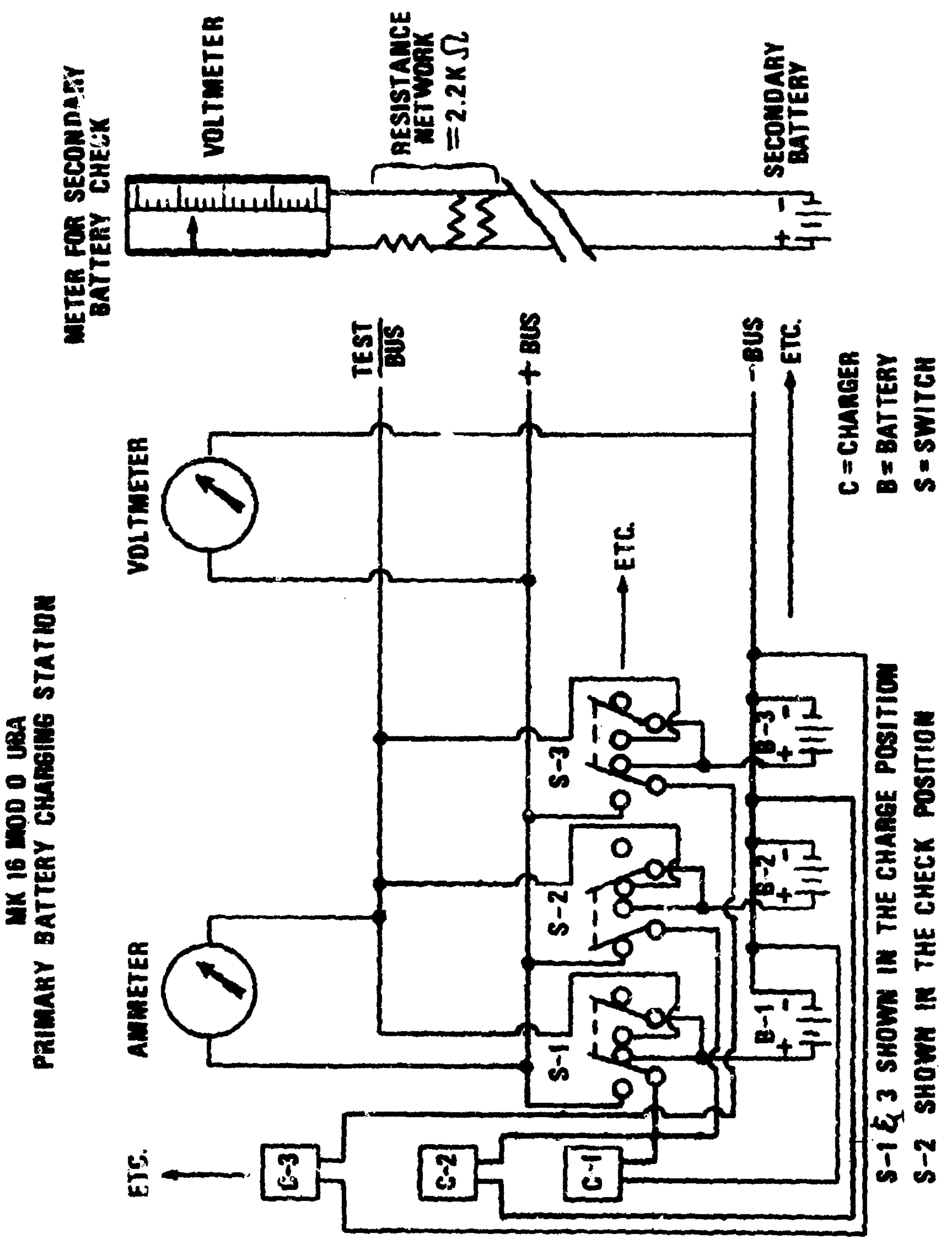
8. To check Secondary Battery

a. Plug into test lead.

b. Strip meter must read Yellow to Green.

c. If battery reads Red, discard battery.

<u>NOTE</u>: To test Primary Batteries, only one may be tested at a time - All other switches must be left in the down (charged) position.




Enclosure (11)